THE NAVIGATOR

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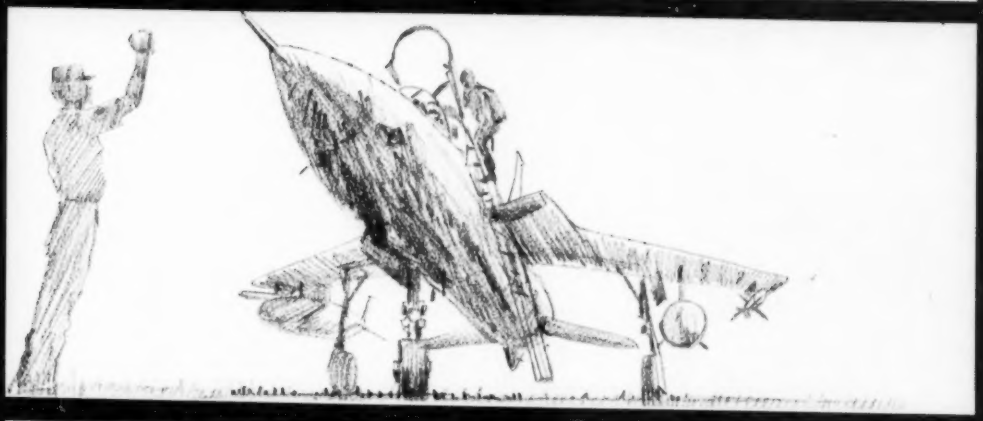

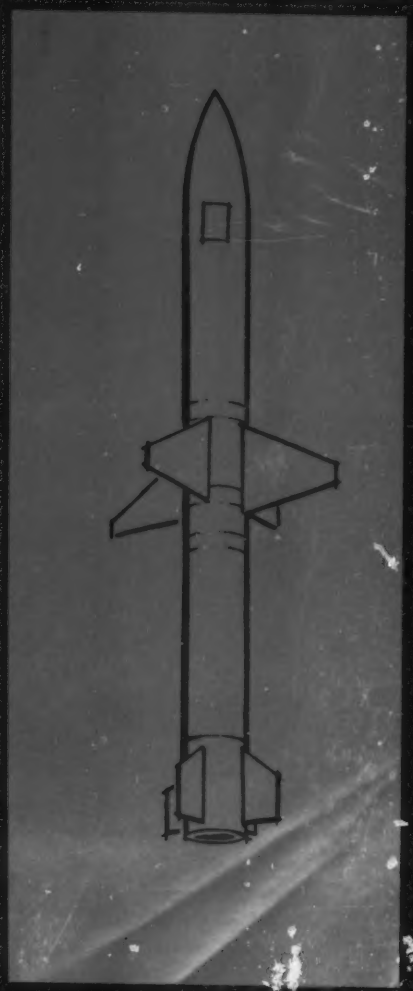

NAVS OF NOTE

COLONEL CHARLES S. HOSTER

Colonel Charles S. "Chuck" Hoster is Chief, Electronic Warfare Division, Directorate of Operations, Headquarters, USAF, Washington, DC. As USAF's "CINC-CROW," Colonel Hoster is the focal point for all Air Staff actions pertaining to planning, training, and employing the increasingly important EW assets of the Air Force. He is also responsible for providing Air Staff inputs for inter-service and inter-governmental EW activities. Recently, he has been very active in assisting allied air forces in improving their EW capabilities, and ensuring that USAF capabilities keep pace with the growing electromagnetic threats. Colonel Hoster received his commission through the Technical OCS Program at Yale University in 1944 and was subsequently "rated" as a flexible gunnery officer. He was a B-29 gunnery officer on Guam in 1945 and served as an operations staff officer in Headquarters, TAC from 1951 to 1953. After another operations staff officer tour in Headquarters, USAFE from 1953 to 1956, he completed navigator and electronic warfare training in 1958 and obtained his "current" ratings. Colonel Hoster then became a B-52 crewmember and Wing EWO of the 7th Bomb Wing. After completing Armed Forces Staff College in 1964, he was assigned to Headquarters, SAC as Future Systems Project Officer. He attended Air War College in 1966-67, and then was Deputy J-3 of the Taiwan Defense Command until 1969. Subsequently, he became Chief of the EW Division, Office of the Joint Chiefs of Staff, until he assumed his current duties in July 1973.

COLONEL PARKER E. REED

Colonel Parker E. Reed is Chief, Navigator Training in the Training Programs Division, Directorate of Personnel Programs, under the Deputy Chief of Staff for Personnel, Headquarters, USAF, Washington, DC. He entered the Air Force upon graduation from Ohio State University and received his wings at Ellington AFB, Texas, in 1957. After a short tour at Ellington AFB as an Instructor Navigator, he attended the AOB school at Mather AFB, and B-47 Combat Crew Training at McConnell AFB, in preparation for assignment to the 380th Bomb Wing. In 1961, he returned to Mather AFB to attend the ASQ-38 Navigator Bombardier Training course and then to Combat Crew Training at Walker AFB. As part of a selected cadre, he was assigned to Homestead AFB, Florida, to bring in the B-52H. Shortly after becoming combat ready in the "H," he was assigned as an operations staff officer with the 823d Air Division. His next operational assignment took him to the 397th Bomb Wing at Dow AFB, where he served as Chief, Operations Plans Division and later, as Commander, 397th Organizational Maintenance Squadron. In May 1968, he was assigned to Eielson AFB, Alaska, where, for two and a half years, he served as Chief, Maintenance Control Division and as Deputy Commander for Maintenance in the 6th Strategic Wing. He next served as the Commander, 307th Organizational Maintenance Squadron, U- Tapao, RTNAF, from October 1970 to October 1971. Upon his return to the CONUS, he attended the FB-111 Navigator Upgrading Course at Mather AFB. Prior to being assigned to his current position in October 1972, Colonel Reed was assigned as a combat-ready FB-111 Navigator-Bombardier with the 380th Bomb Wing.

From The Editor

Reader Survey

The staff of THE NAVIGATOR thanks you for your wholehearted participation in our last reader survey. Basically, the overwhelming majority are pleased with the present format and contents. Your responses provided us with numerous new ideas and we have solicited articles dealing with the most requested subjects, career development, Title 10/command opportunities, operational experiences and new developments. In addition, we will continue to publish significant technical and historical material as well as techniques, short-cuts, etc. Most of you indicated that THE NAVIGATOR should be published on at least a quarterly basis, but budgetary limitations have, thus far, prevented it. We will, however, continue to request the additional issue.

Disappointing was the result of our efforts to compile nav school class directories. Response was very poor, thus we will not be able to supply the rosters as previously planned. Perhaps we will attempt this project again at a future date.

Are You A Professional ?

We, as navigators, comprise one of the finest technically- educated groups in the Air Force. We have been trained to drop bombs on pin-point targets using sophisticated computer systems; we have been trained to practice precision navigation to insure complete photo coverage of a SAM site while traveling at Mach-plus speeds; and we have been trained to employ complex electronic gear to detect, record and, sometimes, destroy the enemy defensive capability. We are professionals— aren't we?

What makes us professionals? Is it the certificates we received when we pinned on our wings, is it the vast technical training we've all accomplished, or are there some intangibles which we usually take for granted? You know—qualities like honesty, integrity, dedication, motivation—the ones that are always indicated on our OERs. Maybe we are embarrassed to admit, or maybe we forget, that these qualities are the ones which are the foundation of our profession and cement it together.

But the issue is even more basic than that. We must remember and continue to emphasize that we were officers before we were navigators and will continue to be officers long after our navigating days are over. And the qualities so important to the navigation profession are even more vital to us as officers. What qualities are necessary to the development of the professional officer? In my opinion, the qualities that made successful the careers of some of our greatest leaders, such as Lemay, Arnold, and Mitchell, are those of integrity and involvement.

Integrity means self-discipline, an uncompromising adherence to a code of ethics. It means sincerity, candor, and a sense of loyalty. It means "telling it like it is" during planning, decision-making, and reporting, even when it means taking a few lumps. In addition, it means developing that state of mind which will enable the performance of every assigned task to the best of your ability.

Involvement, on the other hand, means commitment—to the mission, to the Air Force, and, most of all—to the people—superiors, subordinates, and contemporaries. The people you deal with in daily routines must know that they can trust you, both professionally and personally. I emphasize the need for positive, aggressive action in all endeavors. Don't wait to be assigned a task—identify and perform the required task without being told.

How many of us can honestly say that we are involved or possess the deep sense of integrity required of leaders? If you can't, I implore you to broaden your outlook by considering these words. In the austere period into which the Air Force is now entering, only the most professional among us will survive to progress in our careers. Will you be among us?

This is my last issue as Editor of THE NAVIGATOR. The past year has probably been the most rewarding of my entire career because of the outstanding support I've received and the knowledge I've gained. I'm sure my successor will carry on to bring you only the finest available navigation reading material for your technical and professional development. It's been a pleasure to serve you.

Mike Greenspan

THE NAVIGATOR

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CONTENTS

Navs of Note 2
Are You a Professional? 3
Attack! 5
Airborne Warning & Control: Today & Tomorrow 8
When the Sergeant Says.... Listen! 11
BOHDS (Bailout Hatch Delivery System) 13
"Dead Wood" Effect 15
Preventive Cartography 16
A Different Kind of Cargo 22
An Up-To-Date Look at LORAN C 24
NAVWORDS 29
SSNC Revisited 30

This issue's cover depicts the challenging and exciting world of the Bear, the GIB of the F-105 Wild Weasel. Basically a navigator, the Bear also plays the role of Electronic Warfare Officer and Weapon Systems Officer in the sophisticated electronic environment of air warfare.

ATTACK!

Captain Michael B. O'BRIEN
66th Fighter Weapons Squadron
Nellis AFB, Nevada

Editor's Note: This article has been dedicated by the author to Captain Thomas Zorn and Lieutenant Michael Turose, KIA 17 September 1972, North Vietnam.

The G model of the F-105 Thunderchief (or Thud, as it is affectionately named) is appropriately called the Wild Weasel, and, because of the role it plays, the Weasel emphatically denotes *attack*. The Weasel crew is made up of two crewmembers: the pilot and the Bear, or backseater. The Bear is really a triple-threat: navigator, electronic warfare officer, and weapon systems officer.

Enemy defenses, particularly Surface- to- Air Missile (SAM) sites, are our objective. We're first in the target area with the strike force, and the last out. And in between, we encounter all the excitement and satisfaction that any aircrew can handle.

"First in" starts early on 6 October 1972; the target is a few miles southwest of Hanoi. You've got to know where SAM is; what he's going to do. My pilot is going over the strike force route while I update my maps. SAM hasn't been in the flats southwest of the city, but it's time for him to move in... Two hours before brief time, four before sunrise, we start mission planning and putting it together.

Major Ed Cleveland and I have been "married" for eight months now. He's a Thud driver from way back, now on his second tour, and one of the best in the business. "When the strike force crosses the Black River, we'll want to be slightly to the south..." We trace the path, look at the defenses, getting a feel for how it'll be. You've got to *know* what SAM is going to do, how you're going to find him. Some call it instinct, but it's really only detailed preparation. You think of all the possibilities, you run through how you're going to handle it. Then when it happens, you don't have to think about it or decide; you've been there before.

After the formal briefing, we get together for a flight briefing. Today we're going as a "Hunter-Killer" unit—a Hunter element of two F-105Gs in the lead which locates the SAM sites and suppresses them with Anti-Radiation Missiles (ARMs), while the Killer element of two F-4E Phantoms rolls in with bombs to destroy them. We review our plan and incorporate F-4 tactical considerations. Each player is finely-tuned for his part in the "concerto."

The sun is now high in the east. Prestrike refueling is 20 minutes behind; the radar warning receivers are turned on. The nervous anticipation has given way to the details of the moment. The F-4 element, to the right and line abreast, is always a comforting sight. *I'll never forget the day*

Major Luke Lucas took that MIG-19 off our tail... I cross check the Doppler, then come back to keep the strike force in visual contact while scanning for MIGs. A SAM guidance signal shrieks. "They're warming up their radars; it looks like a SAM day." Time to go to work.

Ed selects the AGM-78 Standard ARM; another SAM guidance signal comes up. A final Doppler check is made. As we come up on Hoa Binh, we receive the first indication of a SAM radar, but he's out of range. Activity picks up with numerous indications of anti-aircraft (AAA) radars, then another SAM radar. The sounds of the electronic environment continue to increase.

So far, it's just been an indicator. Three minutes after the first intercept of a ground radar, we get a persistent SAM guidance signal. When this site to the north of us turns on his radar, we're ready for him. I've got the "78" set for Ed, and he fires. Then excitement reaches a peak as an adversary lets us know he cares. "Valid launch from 10 o'clock!" Our venerable Thud is already moving fast, and Ed pushes the nose over to gain additional speed. Another SAM site to the east comes up as Ed visually acquires the SAM fired from the north. He calls it to the flight, and that engagement terminates with the drastic tug of the G-suit as we out-maneuver the SAM.

The site to the east is still up, and another site comes up to the southeast. Ed has switched to the other "78;" I set it up, and he fires.On the way, the site to the southeast also gives us a SAM to think about. "Condor 1, SAM at two o'clock!", Ed calls on the radio. He starts modifying the jink pattern to cause an effective left turn to the north. The G-suit tugs again, the southeast site is down. Throughout this second engagement, the east site has been up and down, up and down, a few seconds at a time. "Another SAM at five o'clock!", I call to Ed. "Condor 3, SAM at five o'clock", is Ed's warning to the element. The receivers are quiet for a few seconds as our Phantoms go through their SAM avoidance maneuver. AAA radars now become the highest threat as we continue our turn to the left. The F-4's spot the east site on the ground, and the Thud element takes up a protective weave as the Killers roll in. "Condor 3 is in," followed a short time later by, "Condor 3 off to the northeast." Ed, keeping the element in sight, remarks on the results. "They won't bother anyone for a while."

The first five minute pattern has been interesting. The activity continues. "Signal to the north... North of the Red, no threat." For the next three minutes, this and another site north of the Red River play with us. Up and down, up and down... a little SAM radar, a little SAM guidance signal, a little of both... another site across the Red and to the west joins the staccato.

We complete the second pattern at Hoa Binh and turn east. The F-4 element to the right continues their look-out for MIGs, scanning the skies while looking through us towards the SAM threat area. "Signal at eight o'clock!", I call to Ed. It's the site in the flats, the one that's never there. We turn left to say, "hello," then the indication, "Valid Launch! Condor 1, SAMs at 11 o'clock." As the SAMs travel our way, it appears they'll cross in front of us. "Condor 4's got 'em, they're on me." Condor 4 takes his turn at evading the SAMs as Condor 3 visually acquires the site.

The Thuds again provide cover as the Killers do their work. "Signal to the north" are the words as the western site across the Red gets our attention. During our turn to the north, the signal goes down. Meanwhile, the F-4 element's path "down the slide" is bracketed by very heavy AAA. They really keep their birds moving, yet ordnance is right on target. Good work...

The F-4s join up and we turn east again. But, "Condor 3 is bingo." As we begin our turn outbound, another site to the east and across the Red from the previously struck east site tickles our fancy. "Signal

at five o'clock, across the Red." Ed reverses, pulls up and fires our last missile, the AGM-45 Shrike. Condor 2 on the wing also fires his Shrikes. "Valid launch, 12 o'clock," confirms we're an item of interest. But fortunately, no SAMs have been fired and we turn outbound safely.

We're about a minute behind the strike force as we pass Hoa Binh on the way home. I update the Doppler, set in the tanker coordinates, and keep a lookout for MIGs. Even during the trip to the tanker, the electronic environment is active. We get indications ranging from SAM radars to valid launches for the next nine minutes. There's a SAM site out of range to the southwest who just loves to bother us. He's no threat now, but maybe someday we'll meet him.

The action is over, all of 15 minutes in the target area. Poststrike refueling, then recovery, and a most welcome sight— the crew chief, smiling as he sees us taxi in, all our ordnance expended. His efforts made the mission possible. "A good day, chief." The missile lanyard, which remains with the aircraft after an ARM is fired, is a coveted prize, and he accepts it with pride.

Of course, the job isn't done until the paperwork has been completed. So for the next two hours, we reconstruct the mission with Intelligence. Lieutenant Lloyd Tucker is our debriefer and, as usual, he understands how difficult it is to write down all the signal parameters, aircraft parameters, and missile firing parameters at the same time we're trying to attack and survive. By using my tape recorder, it's just a matter of picking the parameters from the tape and the navigation parameters from a map. Tomorrow's mission has already begun as we update the Intelligence Order of Battle. And so, 6 October 1972 is over in the early afternoon.

This one day in Wild Weasel history characterizes the mission: a dedication to the strike force. The strike force can deliver ordnance more accurately if it's not evading SAMs, so when the Weasels do their job properly, the danger to the heavies and other strike aircraft is significantly reduced.

For real job satisfaction, it's hard to match the feeling that you were a determining factor in the strike force returning home from such a heavily defended area without a loss.

So there's an overview of what it's like to be a Weasel. It's much more, of course. It's nice to be able to see outside your aircraft, to be entrusted with the decision-making process on an equal basis, to be able to evaluate your efforts in real time. Little things, maybe... but also, consider the camaraderie with your fellow Weasels, with the Strike pilots and air-to-air guys who rely on you so heavily—call it, if you will, a dedication to people.

Airborne Warning & Control: TODAY & TOMORROW

Major Curtiss L. SMITH and Major Robert H. WESSELS, Jr.
552nd Airborne Early Warning Control Wing
McClellan AFB, California

Next summer, the 552nd Airborne Early Warning Control Wing, located at McClellan AFB, will celebrate its twentieth year of operation as a vital segment of the Aerospace Defense Command. Its mission has slowly evolved from providing 24-hour a day coverage along the western coastal approaches to the United States, to those of providing worldwide deployment support for air superiority missions, extension of existing radar systems and control of interceptor aircraft in areas of the world in which limited radar capability exists.

Many of these capabilities were developed and refined by the College Eye Task Force (CETF). Operating in Southeast Asia since 1965, EC-121D aircraft flew over 50,000 hours in support of air and ground operations. Currently based at Korat Royal Thai Air Force Base, Thailand, the "Connie" has compiled an impressive record for the wing. CETF is credited with assisting in 25 MIG kills and has participated in the rescue efforts of many downed aircrew members.

But the CETF is only one portion of the aerospace defense activities of the 552nd. At a special detachment at Keflavik Naval Air Station, Iceland, wing aircraft operate all-weather, day-night radar and control missions over the North Atlantic. As a resource of Air Forces Iceland and the North Atlantic Treaty Organization, EC-121 aircraft are capable of providing surveillance over thousands of square miles to monitor Soviet air and sea activity. In addition, the "Connie" is credited with rescue assists in the North Atlantic from both military and civilian operations.

At Homestead AFB, Florida, the 552nd maintains a detachment responsible for Atlantic and Gulf Coast airborne surveillance and regularly deploys crews and aircraft from McClellan to augment the detachment for special exercises.

The 552nd has the multiple responsibility of providing training for all combat crews and support personnel; developing concepts, tactics, and procedures; and initiating weapons systems improvements to meet the continually increasing scope of the EC-121.

Contingency plans call for possible worldwide deployment. Consequently, the wing is continually prepared to commit its resources to any special mission or emergency interdiction problem anywhere in the world. Anticipating such possible commitment, each crewmember is well trained and able to meet the special requirements, assigned by DOD, at a moment's notice. Because of its one-of-a-kind aircraft and unique mission capabilities, wing personnel experience almost unlimited travel opportunities.

The navigator's duties on the "Connie" are almost as unique and diversified as the mission he flies. His primary duty is to track the aircraft. Navigation aids are standard on most models of the EC-121: TACAN, VOR, LORAN-A, RADAR and ADF are combined with celestial, map-reading and pressure differential

navigation. Navigation methods are identical to those taught in Undergraduate Navigator Training. In addition, the nav has available an automated navigation system which is supported by the ARN-92 LORAN-C system. The LORAN-C inputs can be fed to a computer which provides the navigator with a latitude and longitude digital readout which is displayed on a Navigation Display Unit (NDU). The LORAN-C system can also be used separately as a navigation aid.

While he has advanced aids at his disposal, the nav is given an important responsibility in addition to his basic requirement to maintain track and compute ETAs. The "Connie" has an airborne radar which is designed to be used by search radar operators to detect friendly or unfriendly aircraft and by intercept directors to identify and direct fighter interception of possible hostile aircraft. To enable the radar personnel to do their job, the navigator must "stabilize" the radar. Using specialized equipment, he "tells" the radar it is in a fixed position over a given set of coordinates, enabling the radar personnel to measure range and bearing to a target for identification much like a ground-based radar would. Although the aircraft is moving, the video presentation remains stationary.

Navigator stabilization procedures are the heart of the airborne early warning theory and, without them, the concept would have no basis. Stabilization procedures can be accomplished in two modes—automatic and manual.

In the automatic mode of operation , the navigator uses LORAN-C inputs that are fed to a computer to provide stabilization. This is part of a multi-million dollar modification to the aircraft and such aircraft are designated the EC-121 "T" model. This highly sophisticated system has, in addition to the LORAN-C mode, alternate modes which are designated LORAN Compensation and DR. All serve to provide the necessary stabilization to meet the operational requirements of the radar mission.

In the manual mode, the navigator must monitor and correct a Ground Position Indicator (GPI) which again provides the needed resource— stabilization. This mode requires constant monitoring and updating to maintain proper stabilization.

Beyond mission requirements, the navigator has a tremendous responsibility to safety of flight. With a relatively large crew compliment of 17-25 crewmembers, he must, at all times, be able to proficiently use every available navigation aid in other than ideal situations. Because of this requirement, the EC-121 has been considered to be one of the best aircraft in which to gain operational experience.

The Airborne Warning and Control System (AWACS) is the next step in the continuing airborne radar surveillance program. Boeing Corporation and numerous subcontractors have been assigned the task of providing a modern airborne radar platform. Currently, the initial brassboard and testing aircraft, and radar systems phase of the AWACS program have demonstrated the capabilities of the highly sophisticated system of electronic surveillance and reconnaissance equipment.

To be designated the E-3A, the AWACS aircraft will house a Westinghouse radar rotodome on off-the-shelf Boeing 707-202 airframes. In the already completed brassboard phase, the E-3A has demonstrated superior state-of-the-art performance as an airborne detection system.

The Westinghouse rotodome is a totally new concept in itself. Using pulse Doppler technology, a high pulse repetition frequency, and operating in the S-band with a specially designed antenna and digitalized electronics, the Westinghouse system will offer a high power, long range, low interference, downlook capability. Low sidelobe radiation will minimize false returns and the digitalized electronics will eliminate ground clutter and non-moving target presentations. The system will also have its own fault detection system able to provide computer readout information for repair or correction of the problem.

Two antennas are required for separate azimuth and height information in the current EC-121 radar detection systems. The E-3A search radar, however, can provide both sources of information with its single antenna.

Also within the rotodome is a Cutler-Hammer AIL IFF antenna array. The AIL AN/APX-130 Interrogator Set will provide air traffic control information through a complete AIMS Mark X SIF subsystem and complete military IFF control through the Mark XII subsystem. During each ten seconds of sweep time, the rotodome will expose over a million cubic miles of airspace to the Westinghouse and AIL surveillance electronics.

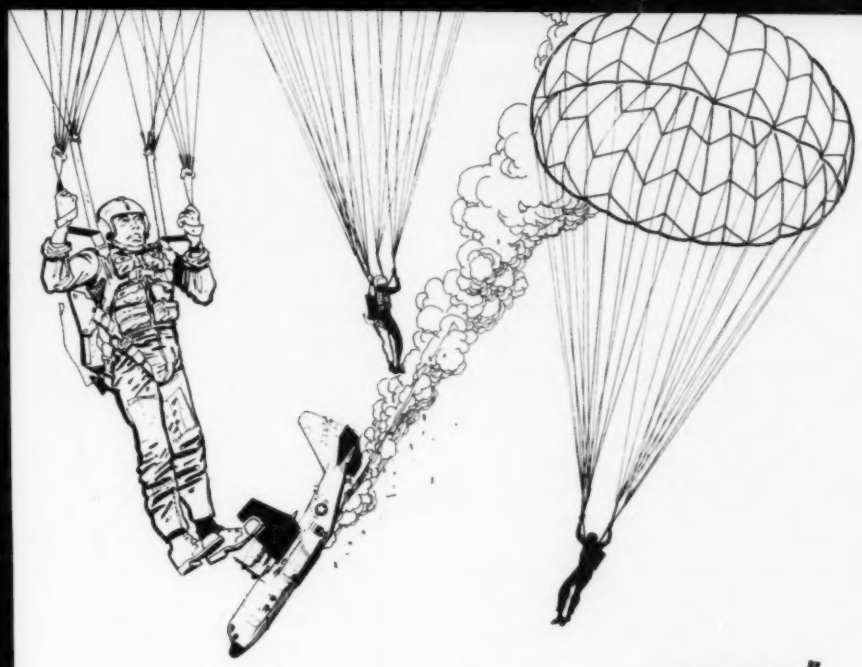
Data processing of radar and IFF/SIF information will be handled by an IBM System 4 Pi CC-1 computer and displayed on a Hazeltine Data Display and Control console. The computer has demonstrated an ability to process over 740,000 operations per second with a mass memory size capable of being expanded to over a million operations per second. The Hazeltine console visually displays the IBM output. The display itself can paint not only radar and IFF target information, but is capable of geographix and map boundary painting as well as alphanumeric data display. Alphanumeric display is intended for use as target identification information and can provide various coded readouts as well as target altitude, heading and velocity information.

The navigator's station in the E-3A will differ substantially from the EC-121 station. Navigation systems will be capable of providing guidance information directly to both the aircraft autopilot guidance systems and to the IBM CC-1 computer and Data Processing Functional Group.

The principal navigation/ guidance information will be provided by twin Delco Carousel IV inertial navigation sets. Inertial system attitude and heading display will be compared with OMEGA radio navigation information and the Ryan Doppler radar velocity information. OMEGA, Delco and Ryan AN/APM-200 Doppler information will be compared to a Northrup AN/ARN-99 OMEGA set for combined three-system accuracy. The Northrup ARN-99 itself is capable of providing accurate positioning to within one nautical mile worldwide using an eight-station OMEGA network.

The AWACS navigator will also have the new AVQ-30XX radar system, in addition to the Westinghouse system, for radar position fixing. The radar systems, the navigation/ guidance function group and the additional standard navigation aids will guarantee the navigator the best possible aids and information for positioning and stabilization.

The AWACS E-3A has been described as "a mobile, fast moving, versatile surveillance, command control center." For total air effort, strike and air superiority, support, airlift, reconnaissance and interdiction, AWACS will prove itself as one of the greatest advances in military aviation technology. But, whether in the E- 3A or the EC-121, the navigator will find a satisfying and fulfilling challenge in his role in aerospace defense.



when the sergeant says.... LISTEN!

Captain Richard CARDOSI
916th Air Refueling Squadron
Travis AFB, California

On the 30th of March 1972, at 2155 hours, an AC-130E Gunship with fifteen crewmembers, call sign *"Spectre 22,"* was downed by enemy anti-aircraft fire over the Ho Chi Minh trail in Laos.

On the 31st of March 1972, at 0925 hours, the fifteenth crewmember stepped off a *Jolly Green Giant* rescue helicopter onto the parking ramp at Ubon Royal Thai Air Force Base.

Fifteen men recovered in less than twelve hours. The rescue took place so smoothly that it had the appearance of a survival school exercise. Why? Who was responsible?

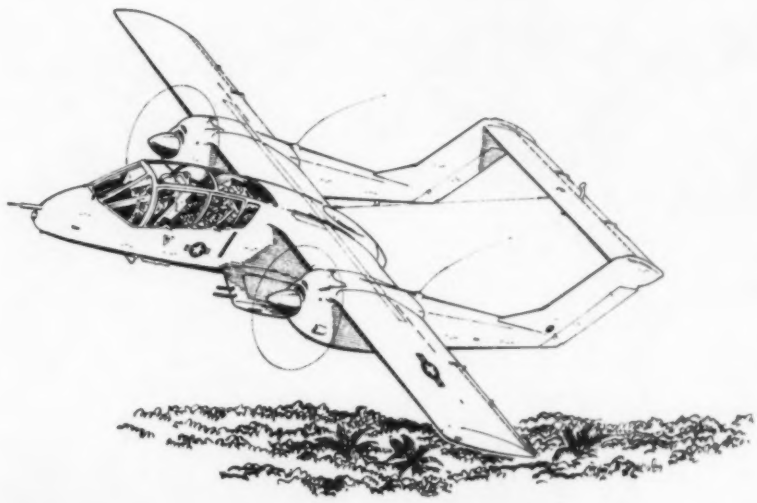
Let's examine this operation, step by step, from the ramp of *Spectre 22* to the ramp at Ubon, and see if we can determine the reason for the success of this unprecedented rescue.

Fifteen men exited that aircraft and pulled "T" handles. Fifteen chutes opened wide. Apparently, the men in the parachute shop do more than just sew on patches.

Fifteen men hit the ground and fifteen survival radios made contact with a *Nail* FAC, a LORAN-equipped OV-10. The communications maintenance people were obviously doing more than just "signing off" periodic inspections.

The *Nail* had been sent by *Moonbeam,* a C-130 airborne command post, to cover the SAR (search and rescue). *Moonbeam* had received the number of good chutes and the exact position of the bailout from a *Redbird,* an infra-red equipped B-57. The *Redbird* had heard the first "Mayday" call, left his area, located the crippled *Spectre* and placed himself above, aft, and to the right of the burning aircraft in a position to observe the crew's egress. He didn't wait to be called, did not request permission to leave his working area; he just sized-up the situation, made his decision, and moved in to help. The spirit of the flyboy hasn't yet been buried in paperwork and regulations.

The *Nail*'s first job was to locate each man, determine the extent of his injuries, and establish communications procedures. During initial contact, the *Nail* assigned one of the four SAR frequencies and a radio check-in time for each man. With fifteen men calling in every thirty minutes, only two minutes could be allowed for each man. For this system to work, it was critical that everyone on the ground have synchronized watches. It worked well, so the rest of the crew must



have paid as much attention to the time hack as the navigator. The *Nail* also determined which men would need assistance and which men could handle the hoist to be lowered by the *Jolly Green.* The only source of this information was each downed crewmember's accurate assessment of his own injuries.

The *Jolly Greens* need to know if a *PJ* (Para-rescueman) should be on the hoist when it is first lowered. If the hoist is lowered to a man and he is unable to mount it because of injuries, the hoist must be raised and lowered again with a *PJ* to assist the injured man. This causes needless delay and increases the helicopter's exposure time to enemy small arms fire. If the small arms fire is heavy enough, it could drive the *Jolly* off before he can lower the hoist a second time. Instead of a rescue, there could be one very lonely man left behind. The *Spectre 22* crew played it straight. Those who needed assistance requested it; those who didn't said so and performed accordingly. During the course of later radio contacts, the *Nail* took DF steers to each man. When he felt he had a good position, he requested a strobe light be momentarily turned on in the IR mode. This confirmed, and accurately pinpointed, each man's position. That the strobe lights all worked complimented the personal equipment shop. That they were used in the proper sequence, along with the radio transmissions for the DF steers, compliments the *Nail* who organized it and the downed crewmen whose discipline made it possible.

This information was relayed to the SAR command post at Nakhom Phanom RTAFB. Armed with the position and condition of each man, the SAR personnel were able to plan their effort in greater detail than would otherwise be possible. Contrary to what some rescued airmen might tell you, SAR personnel are only human. The more information they receive, the more they can do for the man on the ground.

At first light, the *Jolly Greens* and their *Sandy* escorts (A-1Es) departed their bases destined for the pick-up area. A FAC, flying an O-1, directed the *Sandy* in the laying of smoke to help guide the *Jolly Greens.* The *Jollys* started their pick-up run in a pre-arranged sequence, getting vectors, and finally a daylight smoke flare, from the downed airmen about to be recovered. The pickups were uneventful. The return flight to Ubon was a happy one.

The successful rescue of these fifteen airmen was a direct result of the efforts of over one hundred personnel and, indirectly, hundreds more. Credit cannot be given to just one individual, or even one specific group. Bear in mind, however, that the major cause of problems in a SAR is the downed airman. His mental attitude, physical condition, level of training, and his ability to apply that training in a situation of extreme stress contribute directly to the success or failure of the rescue effort. The crew of *Spectre 22* was prepared. They knew how and when to operate their equipment. They understood the organization of a SAR and how they could assist. Finally, they had the confidence and discipline to keep their wits under adverse conditions and aid their own recovery.

The point of this narrative is you, the crewmember. Your rescue depends on you. The SAR personnel will do their job; make sure you are able to do yours. The next time you attend a life support briefing, remember—that sergeant instructing you is doing his part to save your life. So stay awake, and when that sergeant says....listen!

(Bailout Hatch Delivery System)

Lt Col Graeme B. JONES and Major Donald R. MACK
1st Special Operations Wing
Eglin AF Auxiliary Field, Florida

Do you have trouble understanding the majority of articles in this magazine pertaining to modern equipment and "shortcut" navigation techniques? If so, this article is made for you.

Don and I have been in the obsolete airplane business for most of our flying careers. What I mean is that the last radar set with which I had personal truck was an APS-42 in a C-54 in 1964. Give us any combination of astrocompass, handheld sextant, B-5 driftmeter, APN-9 LORAN and whiskey compass, and we will cross oceans/ get lost/ discover new continents.

Recently, we had the interesting assignment of instructing tactical navigation in C-123Ks of the Khmer Air Force. The most amusing part of this five-month stint started a few weeks after we were directed to teach high altitude resupply techniques. Our standard training bundle consisted of a 2000-pound load rigged to a high velocity "ringslot" parachute; uncorrected rate of fall—81 feet per second. This ungainly lump was to be dropped accurately from various altitudes from 3000 to 10,000 feet AGL. The normal computed air release point (CARP) card system is not too effective above 1000 feet because the minimum forward sighting angle from the cockpit of the C-123K is 70 degrees. For example, at 3000 feet, the target would be lost from view when the aircraft was still over 1½ miles out. With an increase in altitude, the forward sight range expands outlandishly, so we determined this type of drop could be made only in typhoon conditions—with the wind directly on the tail. Given this set of imponderables, some other way to sight and direct the aircraft was needed. Since we had no driftmeters, we decided to use the bailout hatch which is located at the front right side of the C-123's cargo compartment. Using the top rear edge of the hole for the "rear sight," the possibility of a sighting angle from 65 degrees to 0 degrees existed. For the front sight, we installed a cross wire stretched across the lower portion of the hatchway and secured at each end by sheet metal screws. The skin is very thin in the hatchway walls, therefore no impediment to bailout was expected since the sheet metal screws would easily pull out when any force was applied. This was adequately demonstrated when surefooted Mack stumbled through the hole—luckily, prior to takeoff.

To determine the "exact" location of the front sight crosswire, we arbitrarily selected a 3000 foot drop altitude, under zero-wind conditions, as a starting point. Using this setup, our only variable was parachute forward throw. Employing standard CARP formulas and ballistics for the 26-foot ringslot chute, forward travel distance was found to be 394 yards. By graphing and a little trig, we calculated at 394 yards out (3000 feet absolute) that the angle from the bailout hatch to the proposed impact point was 21½ degrees. This angle was measured with a Weems

plotter and plumb bob (a bolt on a piece of string) from the aft edge of the hole with the crosswire affixed accordingly. To facilitate lineup, we added two additional wires parallel to the longitudinal axis of the aircraft. One was positioned near the top of the hatchway, and the other directly below it perpendicular to, and on the same horizontal plane as, the crosswire. With this exotic and cost-conscious arrangement, we figured we could track the aircraft directly into the target, call "green light" at the 21½ degree crosswire, and, hopefully, achieve ballpark results. Realizing a no-wind situation would rarely hold up, especially at higher altitudes, a movable slide was hooked to the lower longitudinal wire with which we could vary our sighting angle for changes in head or tail wind components and increased altitude.

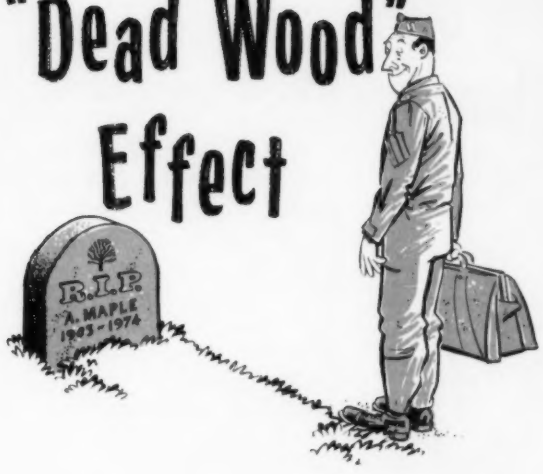
Our next step was to work out partial CARP solutions to determine forward throw and parachute drift effect for altitudes from 3000 to 10,000 feet, with wind velocities from 5 to 30 knots. For varying altitudes, we also figured ground distance in relation to linear movement of the slide on the lower longitudinal wire. This entire mass of data was graphed for ease of reference—mainly because we didn't know what else to do with it at the time. It was our original intention to select drop headings directly up or down the effective wind to avoid offset computations, only varying the forward sighting angle. This could not always be achieved, however, due to operational restrictions, weather, or other unforeseen variables. To enhance our flexibility, we whipped up a compass rose diagram gadget on which we could plot the estimated effective wind and rapidly determine the headwind, tailwind and/or crosswind components. Drop winds were obtained by scanty metro information, surface smoke observations, estimating wind at altitude, and WAGs in between. We boiled down our numerous graphs to a workable set of curves and tables which could be used to "precomp" the first drop. Then, using the results from that drop, we could intelligently recompute subsequent drops. The whole issue was mounted under clear plastic and motivated by hand-held grease pencil.

Our first series of drops, while rather hectic, hinted that we had devised a feasible system. I must admit that we chucked a few in the boondocks but rationalized these away as insufficient coordination between the nav, pilots and loadmasters. I feel compelled at this point to drop a bouquet on our pilots who, though skeptical, not only tolerated our scheme but provided helpful comments, both solicited and otherwise. With additional practice and adoption of a sharp pull up on the drop signal, our accuracy improved to the point where we could get our students into the act. After a brief orientation pejiod, we flew simulated drops on random targets. The trainee picked something small, but easily identifiable, on the ground and directed the aircraft to fly over it. This involved standing between the pilots and giving course directions until the target disappeared under the nose (70 degrees), then rushing down to the bailout hatch to acquire the target (65 degrees) as soon as possible. If the line up from the cockpit (including drift corrections) was done properly, the target showed up close to the longitudinal wires. From then on, it was a matter of setting up any desired offset and keeping the aircraft tracking into the aiming point. Since there are no repeater instruments around the bailout hatch, course corrections were given as in a no-gyro approach. At first, we tried rudder turns to keep the plane level but found that banked turns, decreasing in angle of bank as we neared the drop zone, worked best. We also discovered that 2000 feet was the best altitude for initial training. At 1000 feet, it was almost impossible to make any fine adjustments from the hatch, and 3000 feet was apparently too easy. Two thousand feet gave a sense of urgency to the operation which was necessary to achieve good results. The students picked up the concept and procedures quite easily and were ready for actual drops in a minimum of time.

The actual drop phase of the operation, while not without its anxious moments, progressed more smoothly than expected. Each of our two Khmer aircrew classes included two navigators. The first class was on board as the system was being developed so they were in on the ground floor. Each student dropped approximately 30 times from various altitudes, but usually 3000 feet. Accuracy and confidence improved day by day until they were able to achieve an average circular error of 70 yards. Drop accuracy was dependent on cloud conditions and crew coordination. Weather was definitely a limiting factor as this was strictly a VFR operation. The initial lineup was very important and scattered low cumulus clouds can frustrate an inbound run. Language was a problem in some cases. With our mixed crew, we found out, the hard way, that "turn right" sounds much like "green light" to a Khmer loadmaster with limited English comprehension.

Upon completion of our training program, Khmer C-123 crews immediately employed the "BOHDS" in actual combat support missions within the Khmer Republic. Initial reports indicated they were dropping all five bundles (10,000 pounds) on one pass from 5000 feet with very satisfactory results. I believe the simplicity and flexibility of this air drop method has significantly increased the capability of the ol' C-123.

"Dead Wood" Effect



Major Presley W. DONALDSON, TexANG
136th Air Refueling Group (TexANG)
Hensley Field, Dallas, Texas

The "dead wood" effect is a unique phenomenon that can ruin your whole day. Not only because the "old man" looked straight at you during the last Commander's Call when he said that he was going to trim some of the dead wood from the unit, but dead wood can also affect your radar navigation because of the reflection of electro-magnetic waves.

Many of us have observed how the reflection of electro-magnetic waves in the infrared and the visible spectrum is affected by green trees, grass, leaves, et cetera. As the warm sunlight shines on a green area, the radiant energy is absorbed by the green vegetation and a very cool, pleasing effect is observed. The same intensity of radiation on a dry, dead desert area, however, is unbearably hot because of the reflected radiation.

This phenomenon is similarly true when the electro-magnetic radiation in the radio frequency (RF) spectrum strikes green vegetation. The RF energy is absorbed by the green shrubbery and retained in the plant in the form of heat until it is dissipated from the plant through transpiration. This heat is generated because the water molecules have the electrical property of a dipole. As the RF waves pass through the water molecule, it swaps ends at a rate identical to the frequency of the RF energy. This constant vibration creates friction and, as a result, heat. This absorption of RF energy by green vegetation is the reason that communication is difficult with aircrews downed in the jungle. This is also the principle by which a radar oven heats food while the oven remains relatively cool to the touch. Incidentally, when penetrated by a strong source of RF energy, the human body can also be heated by radar waves. This is not a recommended practice to get warm, however, since there is sufficient flow to the eyes and other very sensitive parts of the body to rid the organs in question of the heat build-up.

The absorption of the RF energy by the green plants and the reflection of it by the dead plants can result in a radarscope presentation reversal similar to the comparison between a frozen lake in the arctic regions as opposed to an ice-free lake. For example, the Toledo Bend Lake on the Texas-Louisiana border was not cleared of trees before filling with water and, as a result, the rising water killed a large area of trees. Jet Navigation Chart JNC-44 depicts a large lake and, when visually observed from the air, the size and shape of the lake appear to be correct. During periods when the water level in the lake is low, there is a very bright radar return from the upper reaches of the lake with a normal water return in the deeper section of the lake. But the bright radar return was not just on the far side of the lake but also in the middle and near side of the lake. Since the upper part of the lake is shallow, the dead trees rising above the water level provide a very good reflection of radar waves, even better than the surrounding terrain with the green vegetation. A very bright return will appear on the radarscope which looks like a city built on the outline of a lake with only a very small water return along the old river channel. (There is only one large city built on the water and it is Venice, Italy. Boy, are we momentarily disoriented!) During periods when the level of the water in the lake is high, a normal water return is observed throughout the entire lake because the water covers the dead trees. Wood is unique in that it will not decay if it is kept under water constantly. Therefore, the tree trunks have all decayed at the normal water level to about the same height and a small change in the level of the water will either expose or cover up the source of a large radar return.

In addition, although the writer has not observed such a situation, similar radar reversals could occur in areas of severe drought or disease where the vegetation has been killed.

The point of this discussion is that although the radar will always tell the truth, we must be able to interpret the truth to select the facts that we need for our navigation. The fact that there is a bright return on the upper reaches of a lake does not necessarily mean that there is a city at that point. It does mean that there is a reflector of radar energy at that point which could be nothing but a lot of old dead trees or stumps that rise above the water level during periods of low water levels.

preventive cartography

Captain John H. HARDEN, Jr.
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St. Louis AFS, Missouri

While significant cartographic achievements in support of space and weapon systems have been made, such as the A-7 map display, computerized digital terrain data for the Undergraduate Navigator Training System, precise target locations, and specialized graphics for Apollo and Skylab, the aeronautical navigation chart has changed relatively little. Sextants, computers, and other tools of the trade come and go, but the chart is still basically a chart. Small wonder then that the aeronautical chart has, over the years, been venerated as the navigator's panacea, with misconceptions growing naturally as a part of that process. Misconceptions can, unfortunately, lead to misuse, and misuse will sooner or later (sooner according to Murphy's Law) adversely affect the mission. At best, this means being "temporarily disoriented" (we never get lost, do we?) and, at worst, it means more takeoffs than landings. Bluntly speaking, your chart, properly used, can save your life. Hopefully, this article will provide information of a practical suggestive nature to help you use the Tactical Pilotage Chart (TPC) and Operational Navigation Chart (ONC) (as examples) to greater advantage. If you want a fancy phrase, call it "preventive cartography."

First things first: what is an aeronautical chart and, more importantly, what *isn't* it? Let's dispel one myth right away. A lot of pilots, and navigators too, firmly believe that an aeronautical chart is a faithful miniature picture of the real world. This is simply not the case. (See Figures 1A and 1B.)

Every natural and cultural feature is not, and cannot, be shown on the chart and everything on the chart does not have material existence in the real world. The rules for what is shown vary. (More on that later.) Charts are, in fact, *schematic* diagrams of *selected* features found over, under, and upon the surface of the real world. More precisely, the aeronautical chart is a graphic representation of a portion of the earth's surface, showing man-made and natural features (such as railroads, roads, rivers, lakes, and mountains), artificial features (such as boundaries, airways, and special use airspace) which serve as landmarks and aids to navigation, and other information considered by cartographers to be of interest to pilots, navigators and other users. Properly used, the chart is a vital adjunct to navigation; misused, it can prove to be fatal. The chief purpose of the aeronautical chart is to help the pilot or navigator get from where he is to where he wants to go—safely.

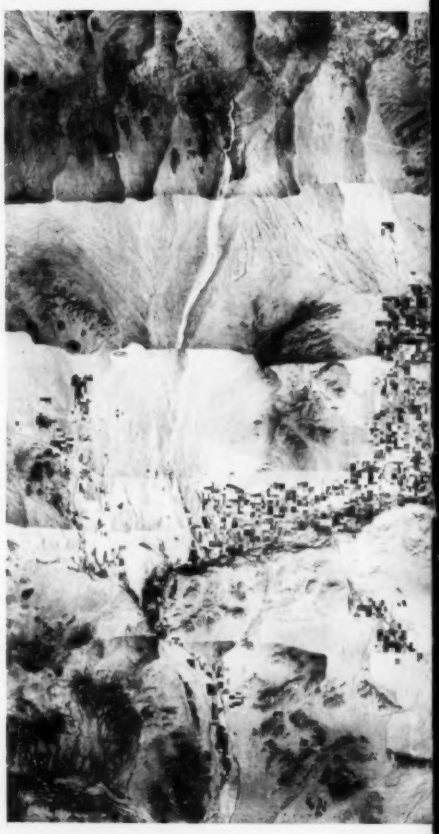


Figure 1A

Figure 1B

Because charts are not true pictures of the real world, some degree of misrepresentation is expected. This, I hasten to add, is not due to cartographic incompetence, but is an inherent quality of all charts. Understanding this important fact should dispel a common suspicion and general lack of trust in aeronautical charts instilled in many users and leave you with a healthy appetite for understanding what charts can and cannot do.

This inevitable misrepresentation is a result of, more than anything else, the problem of scale. A fundamental understanding of scale is necessary for the user to solve the mysteries of the characteristics and capabilities of charts.

Obviously, charts are much smaller than the area which they represent. Chart scale expresses this relationship in mathematical terms. The expression 1:500,000 means that for every one unit on the chart, there are 500,000 units on the earth. The units can be inches, miles, feet, meters, or bottle caps—the interpretation is the same: for every one on the chart—500,000 on the earth.

As the number of representative units on the earth gets *larger* and larger, the chart scale gets *smaller* and smaller. For example, in the series of scales 1:500,000; 1:1,000,000; 1:2,000,000; 1:5,000,000, the scale gets progressively smaller. All this means is that the cartographer has crowded *more* earth units into *one* chart unit. And, the more crowded it gets, the less he can show. Being faced with such an excess of information, *he must selectively show only that information that best serves the purpose of the chart.* The smaller the scale, the more selective is the information shown. Therefore, for reasons of scale, the ONC is more selective than the TPC.

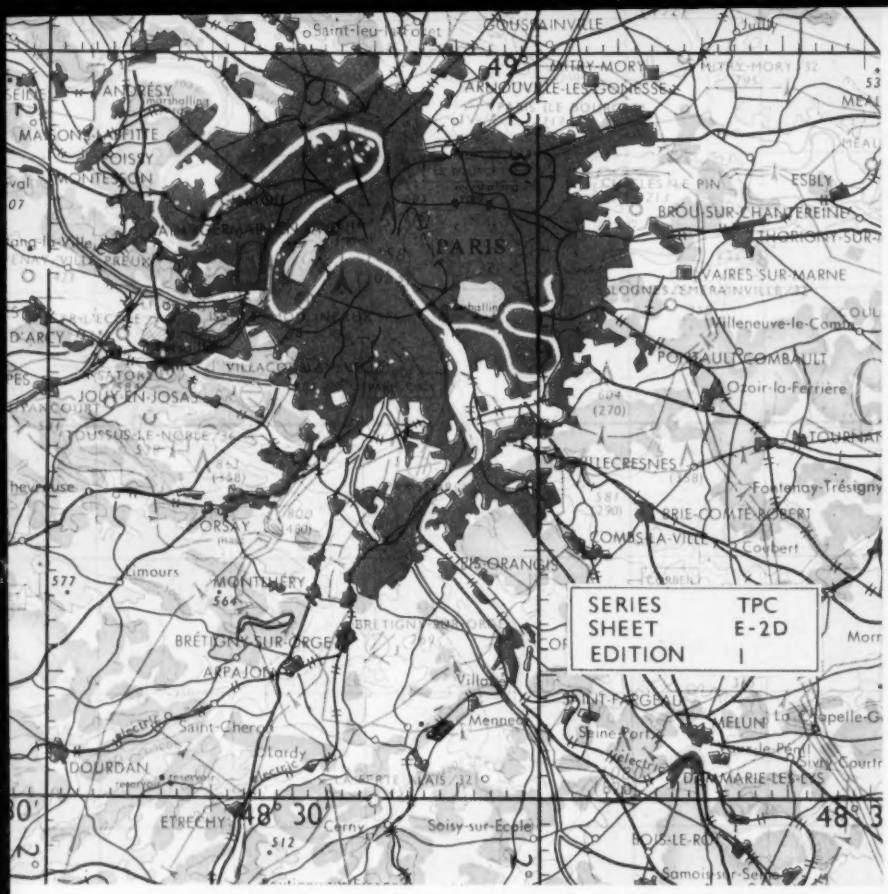


Figure 2A

Figure 2B

One way to distinguish between *small* scale and *large* scale is to think of scale as a fraction (which it is):

$\frac{1}{500,000}$; $\frac{1}{1,000,000}$; $\frac{1}{2,000,000}$; $\frac{1}{5,000,000}$; et cetera.

You will notice that the fraction gets *smaller* and smaller as the denominator gets *larger* and larger. So: small fraction, small scale.

As mentioned before, no attempt is made to show all features on charts. First of all, there is not enough room. Looking again at Figures 1A and 1B, you will see much more information present in the real world than on the chart. The cartographic selection of a small part of the total amount of information in the real world undoubtedly causes the most confusion in interpreting aeronautical charts. Even if it were possible to chart all of the visible features on the photo, the result would be cluttered beyond use. At ONC scale (1:1,000,000), a 14 square mile area on the ground is squeezed into a one square inch area of the chart. Obviously, some information has to drop out. This problem is the cartographer's albatross, for he must exercise wise judgement in selecting which features will be shown, based on an intimate knowledge of what he knows the user needs. As a general guide, the cartographer tries to provide, without clutter, a maximum uniform density of ground features which are of navigation significance. The net result is a "clean" chart, one that has a smooth, even density of information throughout, making it very easy to read. Thus, in highly congested urban areas, which naturally contain more potential navigation features, much detail has to be omitted to reduce clutter and enhance the readability of what is left. The TPC of Paris is a good example of this. (See Figure 2A.) Natural features are no exception, especially in areas containing features too numerous or too small to be shown. In these cases, a representative pattern and a descriptive note are shown.

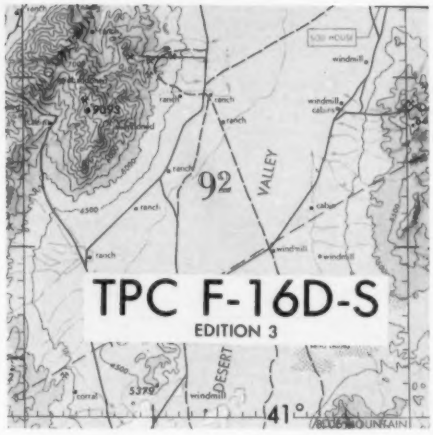


Figure 3

The cartographic requirement for uniform density also works in reverse, especially in sparse areas. To maintain an even density, the cartographer may add features which would not normally be portrayed.

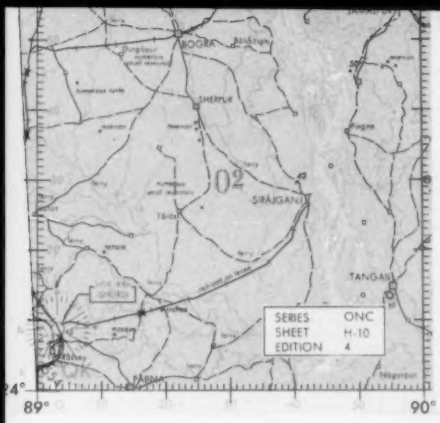


Figure 4

Again, this is necessarily a matter of subjective judgement by the cartographer and accounts for the impossibility of showing faithfully the "real world." These considerations can be invaluable to a pilot or navigator during preflight planning when trying to predict potential navigation fix sources. In general, the cartographer considers currency of information, relief (spot elevations, shaded relief, terrain tints, contour lines and Maximum Terrain Elevation figures), aeronautical information (such as vertical obstructions, airfields, and airspace), and water features to be of primary importance on navigation charts such as the TPC and ONC.

Scale also keeps the cartographer from showing the feature at its true relative size. All but the largest natural features must be symbolically enlarged on the chart for legibility. Referring again to Figures 1A and 1B, you can readily see that road widths, for example, are greatly magnified. The primary road symbol shown covers 2,167 feet in the real world, an obvious exaggeration. Scale also forces the cartographer to generalize the shape of some features, particularly the intricate ones such as lakeshores, coastlines and twisting rivers. For example, the shoreline on an ONC is approximately the width of a fine ballpoint pen line (.007 inches) and covers 583 feet of real world territory on the chart.

All of the previously mentioned restrictions of scale, such as clutter, enlargement, and generalization result in another problem that should be considered by the user, an unavoidable displacement of some features on the chart from their true position. A common example is the railroad- along- the- road situation.

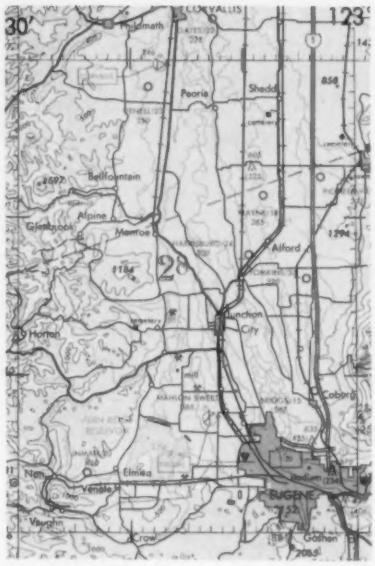


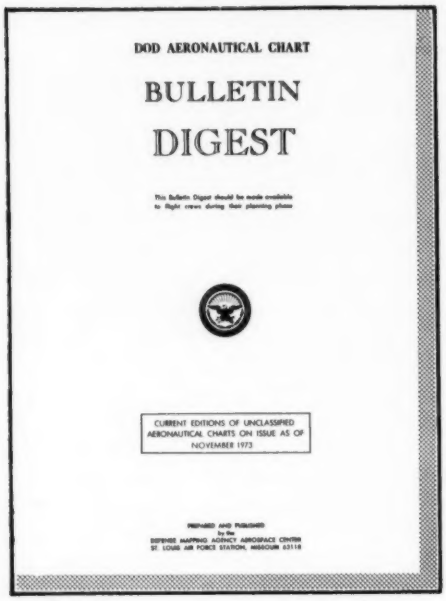
Figure 5

Often the railroad is parallel and close to the road. But the cartographer hesitates to position the railroad in its true relative position because it would superimpose the railroad symbol over the road line symbol and create visual interference, which detracts from chart use, especially when repeated throughout the chart. So he moves the railroad slightly, compromising position in exchange for clarity. This presents no real problem to the user, since, as stated before, the symbols themselves occupy chart space greatly out of proportion to their actual size. The point to remember is that for certain categories of features, there is an unavoidable degree of displacement built into the chart which is inseparable from the cartographic process and which should be taken into account by the crewmember who uses charts. But for all practical purposes, the spatial arrangement of portrayed features, relative to each other (especially terrain features), can be considered correct. (Radar navigators have, for years, used this fact to devise unique "pointer systems" for positive identification of targets and aiming points.)

Air navigators in general, and radar types in particular, have long favored water bodies and associated features for precise fixing. Water features show up well in aerial photographs and are relatively easy to chart, except for one thing: water feature boundaries are charted according to different criteria. Shorelines are shown at mean high water level, while lakes and related water bodies are shown at normal water level. Rivers are shown as solid blue lines if they are water-filled for the majority of time. Non-perennial rivers and streams are shown as dashed lines which imply that they are dry beds more than six months of the year. What this means to you, the user, is that the season of the year and the geographic area (plus the problem of clutter) should be considered during flight planning when trying to predict fix sources. Otherwise, you may search in vain on a July flight, for instance, for that river charted in the desert and wonder why cartographers dislike navigators. On the other hand, you may encounter the situation where a flash flood in the same desert at another time of year results in seeing twice the number of rivers as plotted on the chart. And again you wonder.

This problem of seasonality is not confined to the tropics by any means. It is quite easy for a nice-sized lake with an unmistakable shape to appear as an ideal fix during mission planning, while in reality it may be frozen over and covered with snow and utterly worthless for what you intended. It won't show up on radar (or out the window, either). Moral: never plan all fixes on one type of feature. Consider all the possibilities.

Now that the inner secrets of scale are perfectly clear, you are ready for business. So you pull a chart off the shelf covering your flight plan route. But, wait! How do you know for sure if the chart you have in hand is current? A minor, but crucial, step in your preflight planning should be to consult the latest DOD Aeronautical Chart Bulletin Digest (issued semi-annually in May and November) and any subsequent monthly DOD Aeronautical Chart Bulletin.


DOD AERONAUTICAL CHART

BULLETIN

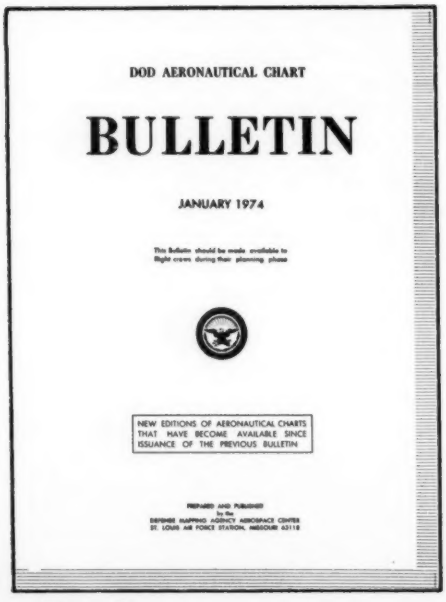
DIGEST

This Bulletin Digest should be made available to flight crews during their planning phase

CURRENT EDITIONS OF UNCLASSIFIED AERONAUTICAL CHARTS ON ISSUE AS OF NOVEMBER 1973

PREPARED AND PUBLISHED by the DEFENSE MAPPING AGENCY AEROSPACE CENTER ST. LOUIS AIR FORCE STATION, MISSOURI 63118

Figure 6


DOD AERONAUTICAL CHART

BULLETIN

JANUARY 1974

This Bulletin should be made available to flight crews during their planning phase

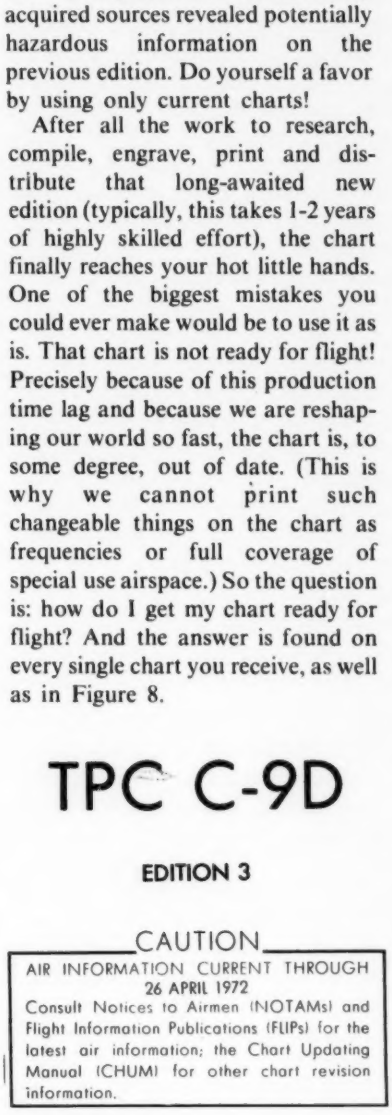
NEW EDITIONS OF AERONAUTICAL CHARTS THAT HAVE BECOME AVAILABLE SINCE ISSUANCE OF THE PREVIOUS BULLETIN

PREPARED AND PUBLISHED by the DEFENSE MAPPING AGENCY AEROSPACE CENTER ST. LOUIS AIR FORCE STATION, MISSOURI 63118

Figure 7

If either of these publications lists a higher chart edition number or a later air information date, then your chart is not current and *should not be used.* In fact, the new edition may have been published because newly acquired sources revealed potentially hazardous information on the previous edition. Do yourself a favor by using only current charts!

After all the work to research, compile, engrave, print and distribute that long-awaited new edition (typically, this takes 1-2 years of highly skilled effort), the chart finally reaches your hot little hands. One of the biggest mistakes you could ever make would be to use it as is. That chart is not ready for flight! Precisely because of this production time lag and because we are reshaping our world so fast, the chart is, to some degree, out of date. (This is why we cannot print such changeable things on the chart as frequencies or full coverage of special use airspace.) So the question is: how do I get my chart ready for flight? And the answer is found on every single chart you receive, as well as in Figure 8.


TPC C-9D

EDITION 3

CAUTION

AIR INFORMATION CURRENT THROUGH 26 APRIL 1972

Consult Notices to Airmen (NOTAMs) and Flight Information Publications (FLIPs) for the latest air information; the Chart Updating Manual (CHUM) for other chart revision information.

Figure 8

One of the best friends a navigator or pilot can have is a CHUM, and I don't mean your drinking buddy. In case you didn't know (and a lot of you don't, we understand), CHUM is the acronym for the DOD Chart Updating Manual.

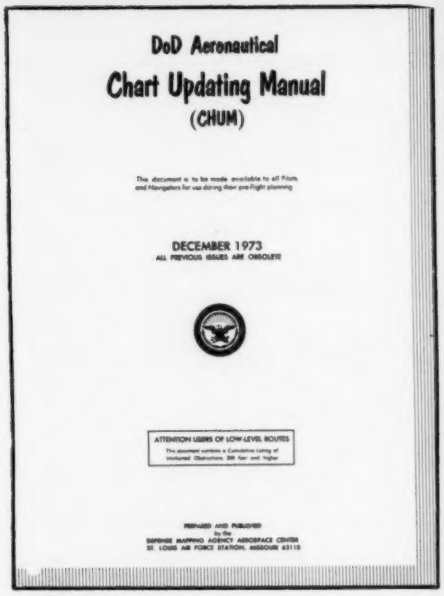

DoD Aeronautical

Chart Updating Manual

(CHUM)

This document is to be made available to all Pilots and Navigators for use during their pre-Flight planning

DECEMBER 1973

ALL PREVIOUS ISSUES ARE OBSOLETE

ATTENTION USERS OF LOW-LEVEL ROUTES

This document contains a Cumulative Listing of Unlisted Obstructions 300 feet and higher

PREPARED AND PUBLISHED by the DEFENSE MAPPING AGENCY AEROSPACE CENTER ST. LOUIS AIR FORCE STATION, MISSOURI 63118

Figure 9

The CHUM is a monthly DMAAC publication designed to inform DOD users of potentially hazardous chart corrections. Spot elevation corrections occupy a large portion of the CHUM, but the great majority of CHUM entries deal with additions, deletions or changes to uncharted vertical obstructions. This is handy information for the low altitude, high speed fliers, even though the CHUM is published for *all* chart users. In fact, your chart is incomplete without reference to it. You should also refer to FLIPs (particularly for airspace and airfield obstruction information) and NOTAMs (for the very latest last minute corrections). But a word of warning is in order. The CHUM, FLIPs and NOTAMs inform the user of all *known* chart discrepancies and other information which could affect flight safety. As always, there is no substitute for heads-up flying. Assuming that uncharted obstructions are lurking in the wild blue helps you maintain a fly-safe attitude.

Now that you know that the chart is always incomplete without the CHUM, FLIPs and NOTAMs, here is another not- so- obvious surprise. Charts are constantly being improved (we think!) and because of the long time required to produce

just one sheet, improvements throughout a chart series such as the ONC are perceived only gradually by the user. Contour intervals, symbols and other rules of the game of chart interpretation change. The source of information for these continual changes is the chart legend itself.

The most important legend information concerns relief.

ONC E-2
AUSTRIA, BELGIUM, CZECHOSLOVAKIA, DENMARK, FRANCE, GERMANY, LUXEMBOURG, NETHERLANDS, POLAND, SWEDEN, UNITED KINGDOM
SCALE 1:1,000,000
Prepared and published by the Defense Mapping Agency Aerospace Center, St. Louis Air Force Station, Missouri 63118. Compiled April, 1971. Revised May 1972.
Lithographed by DMAAC 9-72
SERIES ONC
SHEET E-2
EDITION 15
CONTOUR INTERVAL
1000 feet
Intermediate contours shown only at 500 and 1500 feet
Auxiliary contours shown only at 250 feet
1000
Basic
500
Intermediate
250
Auxiliary
CONTOURS
(Accuracy based on mean sea level)
Contours accurate to within 500 feet
1000
SPOT ELEVATIONS
(Accuracy based on mean sea level)
Maximum vertical error 100 feet .0000
Maximum possible vertical error (none shown) .0000
Approximate or doubtful location, vertical error varies from (none shown) .0000
Critical elevation .0000
Lake and stream elevation .0000

Figure 10

The contour interval is not always constant for a chart series or for a specific chart in the series, and may be changed for a very good reason. On a chart, the contour interval may be changed to better depict the shape of the land in small localized areas. For example, mountain areas may require additional contours to portray a significant increase in slope. Similarly, the number of contours is usually decreased in areas of very flat relief such as swamps and deserts. Also, the accuracy of spot elevations can and does vary from chart to chart, depending upon the accuracy of the source used to produce the chart. These accuracy tolerances are shown in the legend. All kinds of dates are shown to give you an idea of the currency of information. It bears repeating: every time you pick up a chart, examine it thoroughly before use. Remember that the chart legend is the only place where the cartographer can, and often does, tell the user of changes in the ground rules, changes that are designed to improve the chart and make the chart more effective.

Aeronautical charting at the Defense Mapping Agency Aerospace Center is a highly skilled profession manned by expert cartographers and air information specialists with years of experience in portraying and producing chart information. Many have significant prior experience as pilots, navigators, and air traffic controllers. This professional civilian core is augmented by Air Force navigators and pilots in the Requirements Division serving in joint air operations staff officer assignments. These officers act as a liaison between the user and the DMAAC production area to insure that the current product satisfies the operational requirement. Their efforts are justified only so long as you, the user, let us know of your success or failures with our products. The state of the art of cartography and operational weapon systems is constantly changing. Your responsibility as part of this continuous effort is to understand how to use the aeronautical chart and to let us know of suggestions, corrections, criticisms and comments that might improve the product and result in a safer, more effective mission. There are two easy ways for you, the operational user, to communicate your correction or suggestion to us. One way is to annotate your corrections directly on the chart and forward it to DMAAC.

ONC G-20
EDITION 10
Users should refer corrections, additions and comments for improving this product to: DIRECTOR, DEFENSE MAPPING AGENCY AEROSPACE CENTER, ST. LOUIS AFS, MISSOURI 63118. ATTN: PP

Figure 11

We would be most happy to forward a replacement chart because we are interested in receiving corrections to our charts based on actual inflight use, which, in our opinion, is the best test and evaluation situation possible. In lieu of forwarding a chart, the user can fill out the DMAAC Form 8325/1, Correction/Suggestion Card, which is available in all Base Ops.

The form is particularly handy to use during mission planning while the idea is still fresh in your mind. Every effort is being made to keep DMAAC products current, accurate and tailored to your requirements. Lacking the gift of prophecy, we cannot correct an error unless we know of its existence. And that is where you come in. We need feedback from the user. That makes you the critical ingredient.

Getting more out of your aeronautical chart boils down to understanding a few essential points:

1. Aeronautical charts are characteristically not faithful representations of the real world, but are really schematic diagrams of selected features.

2. This misrepresentation is due to the inflexible limits of scale as well as certain cartographic considerations.

3. The chart is potentially hazardous and incomplete without reference to the CHUM, FLIPs and NOTAMs. Reading the legend helps, too.

4. Finally, a system does exist that allows direct input from the user into the quality of the charts he uses. This is perhaps the most important point because, as usual, the human equation is the key to making subservient systems—be they complex avionics, simple hand tools, or charts—work effectively.

A DIFFERENT KIND OF CARGO

Major Robert E. REITER, Jr.
and
Major Robert J. BERNIER
453d Flying Training Squadron
Mather AFB, California

The increasing complexity of present day aerospace systems demands more capable navigators and changes the roles that they play on the air superiority team. Not only must today's navigators be competent in their specialties, they must also be able to develop and integrate new concepts into their missions to insure continued reliability to meet new requirements. In no area is an ability for innovation more critical than in SAC's drone program. The degree of success achieved by the air-launched drones is due, in a large part, to the navigation techniques, imagination, and creativity of the navigator crewmembers. In the drone program, mission success is measured by the accuracy of drone flight over its desired route. Because the drone flight profile is totally dependent on navigation inputs, precise navigation is essential.

Performed by the 100th Strategic Reconnaissance Wing at Davis-Monthan AFB, Arizona since 1964, the SAC drone program mates the DC-130 *Hercules* airframe with modified Ryan *Firebee* drones to conduct its mission. The navigation challenge by this unmanned system is met by the combined effort of four navigator-rated specialists aboard the DC-130: the navigator (AFSC 1565), two launch control officers (LCOs, AFSC 1575); and the airborne recovery control officer (ARCO, AFSC 1575). The navigator is responsible for the precise positioning of the launch aircraft, especially during the critical phases of the drone's flight. The LCOs are responsible for the accuracy of the mission planning, the drone systems checkout, drone engine start, and launch of the drone on the navigator's hack. The ARCO is responsible for accurate drone navigation, terrain clearance, and stability and control. While all of the officers have specific tasks to perform, their duties and responsibilities overlap and considerable crew coordination is required throughout the mission. To illustrate this, let's take a look at the typical mission.

Prior to launch, the drone engine is started, and all systems are made ready. From airborne launch to the specialized inflight recovery by helicopter, the drone's

profile can be monitored by drone specialists aboard the launch aircraft. The mission begins at the Strategic Air Command headquarters at Offutt AFB, Nebraska, with a request to satisfy a particular requirement. Former DC-130 crewmembers at HQ SAC initially plan the mission to satisfy the mission requirements and provide exact drone launch point coordinates and altitude requirements. The mission is then sent by message to the operational unit for final planning and to other agencies for coordination.

When the mission is received within the unit, the crew tasked to fly the mission is alerted and planning is started immediately. The crew converts the drone message into a precise flight plan. To insure error-free planning, each LCO independently plans the drone flight. Frequent cross-checks are made to resolve any differences. The more intricate the mission, the greater the amount of coordination required since an error-free plan is the minimum acceptable.

The navigator's and the ARCO's responsibilities are based upon monitoring the drone during its free flight and their planning begins as the LCOs complete theirs.

The ARCO reproduces the LCO's drone flight plan on a separate chart during the mission planning session. The ARCO's chart includes a presentation of the drone flight profile, terrain features and each programmed event. When the drone profile is completed, the navigator and the ARCO coordinate and plan the DC-130 route after launch, relative to the route of the drone. The ARCO's means of remotely commanding the drone is his Microwave Command Guidance System (MCGS). The navigator must consider the DC-130 airspeed, airspace restrictions and many other factors to plan for the best monitor route. Because the best conditions for the ARCO are usually not the best for navigation, compromises are necessary. The DC-130 route is finally depicted on the navigator's log and chart as well as the ARCO's chart for use inflight.

The entire planning process usually requires about five hours of intensive work, but this can easily double for a complex mission. When the planning is complete, detailed route information is sent to HQ SAC and the mission is ready to be flown. In the view of the LCOs, ARCOs, and navigators on the crews, the most tedious part of the mission is the planning phase. Crews develop a "pride of authorship" while planning a mission and they are anxious to see it work successfully.

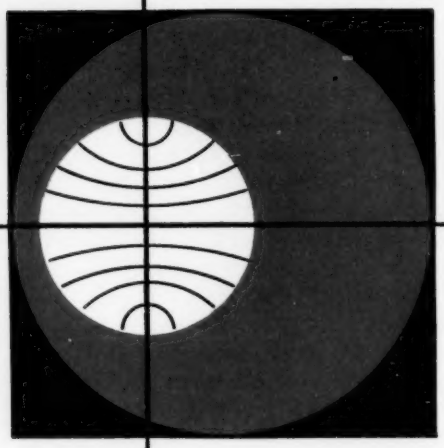
The day of the mission begins hours before takeoff when the LCOs report to begin checking out the drones. The ARCO's preflight duties include the critical alignment of the drone mission plotting board to suit the particular mission. The LCOs and the ARCO then check out the compatibility between drone and the MCGS. To complete the preflight, the LCOs accomplish a walk-around inspection of each drone in preparation for takeoff.

By the time the mission is finally underway, the work of the LCOs is nearly complete. The most critical aspects of their duties are over. The mission now rests primarily with the ARCO and the navigator.

From the launch point, when the navigator notifies the crew, until recovery of the drone, close crew coordination is essential. The LCOs accomplish last-minute confidence checks and prepare for drone engine start. The ARCO pre-positions his equipment and stands by for launch. The navigator obtains fixes and updates the DC-130 position and heading in a continuous cycle. Five minutes prior to launch, the LCO starts the drone's engine and completes the drone's power checks. If all checks are satisfactory, the drone is ready for launch.

On the navigator's hack, the LCO launches the drone and the ARCO commences the monitor of the drone's flight, reporting to the crew the along-track movement of the drone. Periodically, the navigator provides the ARCO with an updated position of the launch aircraft. When the drone is on track and on profile, there is little for the ARCO to do. His performance is truly measured, however, during drone deviations from track, or unusual gyrations. During these occasions, close ARCO-navigator and ARCO-LCO coordination is critical. Survival of a drone depends upon this coordination. The LCO, normally the most knowledgeable of drone systems operation, acts primarily as a recorder during the drone's free flight, but in his specialty, provides malfunction analysis information and possible solutions for drone problems. This information, coupled with navigation updates and readouts from the drone equipment, keeps the ARCO's job both interesting and demanding. He must plan ahead, but react immediately. Decision time is short; errors costly. One inattentive moment or distraction can result in a drone crashing into a mountain or flying out of control. To his credit, the ARCO has enhanced mission success. The four navigator-rated officers, acting in concert with the entire eight-man DC-130 crew, have helped make the operational drone program successful. The degree of professionalism exhibited by the SAC crews is echoed by the praise received for their continued mission success. The drone program has generated interest and speculation throughout the Air Force concerning future applications of drones. Navigator personnel, operating the present generation of drones, have demonstrated that they will be an excellent source of talent in any future drone program.

an up-to-date look at LORAN C



William D. MONTJOYE

The ideal navigation aid is one that incorporates all the advantages of various systems without any of the disadvantages, but in reality, this is impossible. The closest approximation to an ideal system is one which is a successful integration of various subsystems utilizing numerous inputs from a variety of sensors (inertial, Doppler, visual, infrared, et cetera) and incorporates a logic circuit which eliminates bad data or, at least, uses the best available data to make a decision. The function of integrating sensor outputs and making decisions is most often left to the navigator. Unfortunately, the equipment available to the navigator for processing the data received is not always comparable in quality.

Until now, LORAN C has not been able to carry its fair share of the Long Range Navigation load, not because navigators don't know how to use LORAN C equipment, but because LORAN C equipment has not been able to provide the navigator with an input that was as good or better than that he could obtain from other sources.

For obvious reasons, self-contained systems such as an Inertial Navigation System (INS) or a Doppler radar are excellent for military use and have the advantage of being useful regardless of geographical location. However, the gyros in the INS drift, and accuracy degrades with time. The gyros' inertial reference needs to be updated occasionally, and each installation requires two Inertial Measurement Units and a computer for the necessary reliability. Likewise, Doppler radar needs to be bounded by a stable reference to prevent large errors from accumulating in the dead reckoning system. A station-referenced system such as LORAN provides high accuracy, reliability and continuous positioning, but suffers from limitations of coverage.

There is very little similarity between LORAN C and its predecessor, LORAN A, because LORAN A does not have the advantages of cycle-matching, a process which can result in 200′ accuracy in good coverage. LORAN C also enables the navigator to acquire stations easier, track longer, track different slaves simultaneously, acquire slaves and master independently, and maintain a continuous position fix. With LORAN C, the navigator can obtain position data accurate enough to bound his Doppler or update his INS. LORAN C transmitter sites are some of the most accurately surveyed locations in the world.

The many advantages of LORAN C are obvious and it is unfortunate that it was not named something else. The types of receiving equipment available today range from simple displays of time differences to those that provide left and right steering information, latitude and longitude, or plot your course on a chart.

LORAN C is in the same category of hyperbolic pulse radio navigation aids as LORAN A. The concept of LORAN was first applied in 1941 as LORAN A, still a widely-used navigation aid despite some shortcomings. It is sufficient to say that the operating frequency of 1850-1950 kHz is not the best for reasons of accuracy and reliability because of high propagation losses occurring at medium frequencies. These losses greatly affect range. In addition, there is a great loss of predictability due to skywave interaction with the atmosphere, and natural and man-made objects which constitute a significant fraction of the wavelength.

In 1945, it was decided to develop a system operating at 180 kHz and to utilize pulse envelope matching like LORAN A. The pulse envelope matching was soon abandoned because the accuracy of locking on to the

transmitters was not sufficient. Instead, a method of locking on to the individual cycles of RF energy within the pulse was developed and a much higher degree of accuracy was obtained. This system became known as CYCLAN (Cycle Matching LORAN).

After the Air Force submitted a requirement in the 1950s for a highly accurate tactical bombing aid, the system evolved into CYTAC. CYTAC operated at 100 kHz, used the same method of resolving ambiguities, the same pulse system, and was very much like the present LORAN C. In 1955, the Navy and Coast Guard assumed responsibility for CYTAC and situated it on the east coast as a navigation aid. By 1958, it was operational and was renamed LORAN C. The east coast chain was soon followed by LORAN C chains covering the Mediterranean, the Norwegian Sea, the Aleutian Islands, et cetera. There are now 31 transmitting sites that provide coverage over 12,000,000 square miles. It is now possible to fly around the world in the northern hemisphere in continuous LORAN C coverage, thus maintaining continuous position data. The North Atlantic great circle routes are almost entirely within continuous groundwave coverage, and skywave coverage extends down to the Azores where reasonable accuracy can be obtained at all times. Over the Pacific, continuous coverage is available from San Francisco to Burma; the only drawback being poor angles of cut in some instances.

Like any other communications system, LORAN C is composed of a transmitter, receiver, and the intervening propagation medium. Hyperbolic radio navigation aids operate on the principle that the difference in time of arrival of signals from two sources is a measure of the distance from the observer to each source. The locus of all points that provide the same time difference is a hyperbola with the two sources as focii. The hyperbola is also a line of position (LOP) and all that is needed for a fix is another LOP, or in other words, a third source (Figure 1). The accuracy of the fix depends on the navigator's ability to measure the time differences with his equipment and his knowledge of the propagation conditions.

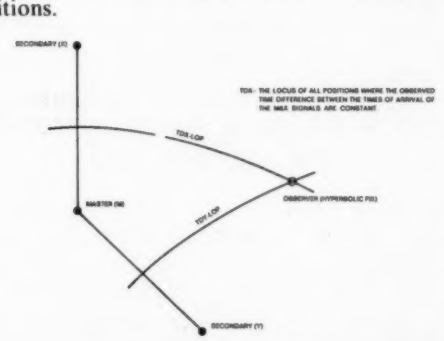


Figure 1 **HYPERBOLIC FIX GEOMETRY**

LORAN C chains are arranged much like any other hyperbolic navigation aid, with one significant difference. The baseline lengths in a LORAN C chain are quite long, varying from 600 to 1200nm which means that anywhere in the desired coverage area, the signal from the master and one or two slaves are clearly visible. With other hyperbolic navigation aids, the geometry of the system becomes the limiting factor long before the signal is lost. The LORAN C chain is configured with a master and three or four slaves arranged around it roughly on the circumference of a circle (Figure 2). This, in itself, makes a difference because the stations do not operate in pairs like LORAN A, but rather, operate so that two position lines are simultaneously available. This is possible by the fact that the master station is always received first and differentiation between slaves is made on the basis of their position on the time base. For example, the Sylt transmitter (a slave of Faeroes in SL 3) operates with a time delay of 26,000μs so its readout will always be within the range of 26,000 to 32,000 μs and no other station can occupy this position on the CRT time base. If a slave is acquired first and identified, it is relatively easy then to look along the timebase for the missing master and other slaves. It is up to the navigator to select the combination that gives him the best fix and lock it into the receiver. The receiver will provide continuous time difference readouts every second or so and track until the signal is lost.

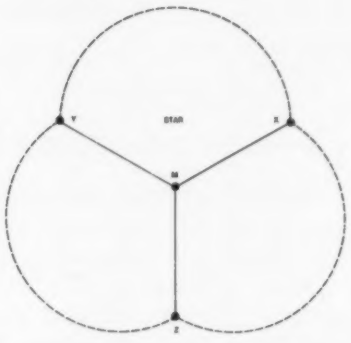


Figure 2 **LORAN C SYSTEM CONFIGURATION**

The LORAN C system is a combination of a pulse system, where difference in arrival time is measured directly, and a continuous sine wave (CW) system where the time difference is measured as a function of the apparent phase shift between signals of the same frequency from different stations. The latter method is so accurate that it is used in geodetic surveys. The matter of discriminating between groundwave and skywave in the CW system, however, is the great disadvantage, so a great deal of technical difficulty was overcome when the present method of providing phase comparison on the third cycle of the pulse was developed for LORAN C.

Each LORAN C chain is unique in that it has a specific Group Repetition Interval (GRI). The GRI is of sufficient length to allow the master and all the slaves to transmit their respective groups of eight pulses (nine for the master), and assure that no two stations overlap. The GRI is, therefore, a function of the number of stations in the chain, the distance between them, and the adjacent chains (because of the need to eliminate mutual crossing rate interference). This makes it easy to identify stations within a chain and to switch chains.

The primary group of eight pulses are transmitted once every 1000μs (Figure 3A). Eight pulses are used in order to take advantage of the fact that at low frequencies (i.e., 100kHz), there is a limit to the amount of available radiated power. If the receiver incorporates a synchronous detection system in the front end, this limit is overcome by the fact that the eight pulses are superimposed by the receiver and it sees an effective radiated power of eight times the actual. In this type of radiation, the signal- to- noise ratio is improved because the noise tends to average itself out over the period of transmission. The transmission format of eight pulses also helps to overcome the effect of long delay skywaves and atmospheric interference.

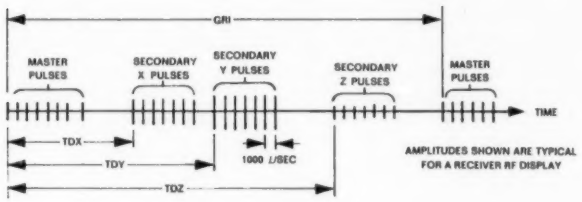


Figure 3A **EXAMPLE OF RECEIVED LORAN C SIGNAL**

If we take a look at the individual pulse such as seen on timebase 3 of an AN/ARN-109, we see that it is made up of a great number of cycles of RF energy. The pulse is typically 270-300μs in duration, but receiver (and navigator) operation is keyed to the leading edge of the pulse, identified as the third cycle (Figure 3B).

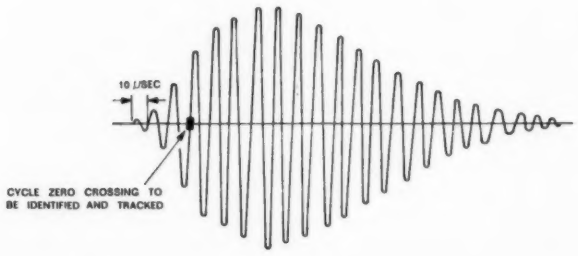


Figure 3B **LORAN C PULSE**

Another obvious fact is that comparing pulses, cycle for cycle, would be much more accurate than matching the envelope of the pulses such as in LORAN A. For this reason, LORAN A receivers, modified to receive LORAN C signals (a frequency converter is on the front end), do not give better than 10-12nm accuracy, even in good cover, because a match of better than 2 to 3 cycles cannot be achieved. The phase comparison system in a good LORAN C receiver has an instrumental accuracy of 0.1μs which is to say that distance is measured in hundreds of feet. For obvious reasons, the navigator would like to be able to select the same cycle from the various stations to resolve any ambiguities and obtain the same degree of accuracy on his LOPs. If he were on the third cycle in the master pulse, and the fourth or fifth from the slaves used for a fix, he would either need to apply the 10 to 20μs difference to his readout or accept the error in his position fix.

The rationale of selecting the third cycle of the pulse is based on the latest time in the pulse where the signal is sufficiently strong to track and be free of skywave interference. The LORAN C pulse, because of its length, will always be contaminated by skywave (Figure 4), hence the 30μs point is selected as the sampling point because no skywave contamination can occur prior to this and, by that time, the pulse has reached 60% of its peak amplitude. Normal groundwave measurements are made using this point. However, if extreme accuracy is not important, the operator can cause the receiver to track on the fourth through the eighth cycle and considerably increase the range of the receiver. This is often of great value in areas where skywaves are beginning to interact. It is often possible to maintain lock and track beyond 2000 miles in daytime.

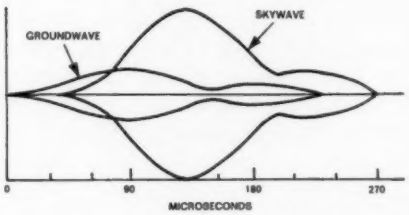


Figure 4 **THE BASIC LORAN C GROUNDWAVE AND SKYWAVE PULSES AS RECEIVED AT 1000 MILES IN DAYLIGHT**

All LORAN C transmitting stations are equipped with Cesium Beam frequency standards. The stability and accuracy of these standards permit each station to derive its own time of transmission and operate in a "free running" mode. The objective in controlling LORAN C chains is to maintain a constant time difference for each pair of master-slave transmitters at a fixed point in the

coverage area. When propagation conditions vary, or some other phenomenon occurs that changes the time difference by more than the allowable tolerance, changes are made to correct it. If a station gets out of tolerance, it emits a blink code to warn users of this condition. The master does this by blinking its ninth pulse, while the slaves do it by turning its first two pulses on and off.

The collection of calibration data is carried out such that the standard is assured. Each monitor site is carefully surveyed, either by satellite positioning or first order survey, to maintain the reference for all other elements of the chain. From this data, such things as surface conductivities are estimated to assist the serious user in predicting accuracy. During the time LORAN C has been in use, its reliability has been maintained at better than 99%.

As in all RF communications systems, the atmosphere plays a big part in LORAN C. The LORAN C transmission at 100 kHz follows the general curvature of the earth (groundwave). It also interacts with the atmosphere, producing bouncepaths (skywave) of different lengths (Figure 5), depending on the height of the ionosphere, which is a function of latitude and time of day. The low frequencies (LF) tend to behave better than the higher or lower ones in this communications environment. For instance, Very Low Frequencies (VLF) which travel the skywave or waveguide mode suffer from lack of real time knowledge of the affect of atmospheric conditions on the transmission. The diurnal effect is more severe than at LF and a navigator would need several sets of charts just to keep up with the changes over a short trip. On the other end of the spectrum, the higher frequencies are similarly unpredictable or are unusable at long ranges because of their line- of- sight properties.

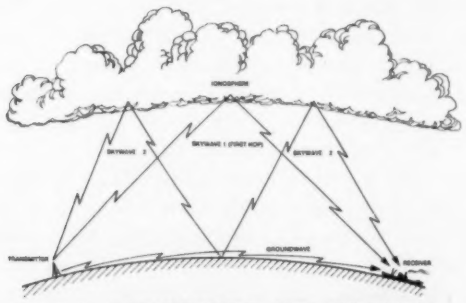


Figure 5 **GROUNDWAVE AND SKYWAVE PROPAGATION PATHS**

The average measurement for reception of LORAN C groundwave, using a LORAN C/A receiver, is 1150nm with some instances of up to 1500nm. Ranges in excess of this are probably skywave. The groundwave is affected by surface conductivity and, consequently, differences show up between land and sea and between the northern and tropic latitudes; the latter in both cases being the one with the greatest range.

Skywave properties of LORAN C, at 100 kHz, are very stable and do not exhibit the fading and splitting associated with LORAN A. Hence, with a good LORAN C/A receiver and a good knowledge of atmospheric conditions, the navigator can accurately position himself at great distances from a LORAN C chain. Since the time of arrival of the skywave will change slightly as range changes, and because of the change in height of the ionosphere with time of day, the navigator need only make minor adjustments to compensate. At short and intermediate ranges (500-900nm), the skywave is not of particular concern since the time delay, even in daytime, is beyond the third cycle of the pulse. At 1000nm or greater, however, the skywave must be taken into consideration. The most probable skywave present will be the first hop E, unless you are in the tropic zones.

Figure 5 shows the basic LORAN C pulses as received at 100nm in daylight and indicates the interaction of the groundwave and skywave. It should be evident why the pulses sometimes cannot be separated visually. Occasionally, the pulses arrive 180 degrees out of phase and a composite pulse is displayed that looks like two pulses (Figure 6A). What has happened is that there has been cancellation resulting in a null at that point. When the pulses arrive in phase, they appear as in Figure 6B. The skywave can be put to good use by indexing the receiver into the pulse to the cycle that provides the best tracking and then making the corrections in the plot.

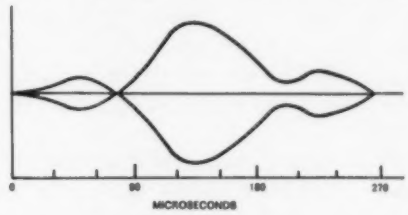


Figure 6A **LORAN C COMBINED PULSE ENVELOPE, GROUNDWAVE AND SKYWAVE AT 1000 MILES, DAYLIGHT, 180° PHASE DIFFERENCE**

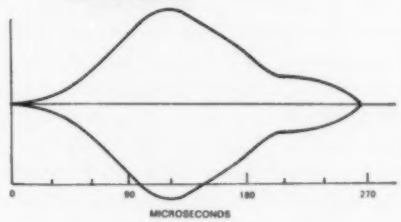


Figure 6B **LORAN C COMBINED PULSE ENVELOPE, GROUNDWAVE AND SKYWAVE AT 1000 MILES, DAYLIGHT, IN PHASE**

There is a considerable variation in skywave propagation during twilight. There is evidence that as night conditions prevail, the strength of the skywave declines and finally collapses. This collapse of the skywave is then followed by the buildup of a skywave of longer delay, but greater strength. There also appears to be difference in the North/South and East/West propagational characteristics; the latter being the stronger by about 20%. Skywaves are also affected by traveling over a land path but this does not happen very often because the chains are laid out to avoid this long delay as much as possible.

Atmospheric noise, with the possible exception of the presence of considerable corona discharge, does not appreciably affect a good LORAN C receiver. Measurements were made in the presence of severe tropical thunderstorms and it was shown that the receiver could still track a relatively weak signal. It has been speculated upon that the reason for such a pessimistic forecast in other papers on LORAN is that the average noise figures were applied to a system without synchronous detection. Even with a relatively short time constant in the airborne receiver, the signal enhancement properties of a good LORAN receiver are able to cope with noise spikes and random noise.

The most severe problem in LORAN C operation is in the area of frequency sources near the 90-110 kHz band. These transmissions can adversely affect range, but in most cases can be filtered out. This problem was created in the early days of LORAN development when frequencies were allocated. It is, fortunately, confined to the European area, and to a few isolated areas in the Pacific. A narrower bandwidth would do more harm than good, so external noise is something that must be taken into consideration.

LORAN C receiving equipment can be no better than its antenna. The modern installation has evolved from the old long wire to a flat plate which provides a much better signal- to- noise ratio and more freedom from interference. The commercial users of LORAN C and the Air Force T-43 both use a plate antenna.

Where there is a need for long range navigation, and accuracy and dependability are requirements, the user must demand the current state- of- the- art in LORAN C receiving equipment. This equipment, first of all, must be true cycle-matching hardware. It should also carry the designation LORAN C/A, indicating that the receiver is designed to receiver LORAN C as well as A. The receiver may well have a provision for LORAN D also, as does the ARN-109. These receivers incorporate the capability to visually and electronically match the pulses being received. This is especially important since the third cycle in each pulse must be indexed as well as insuring the same cycle from the master and slaves. A CRT provides the visual match, while the indexing meter provides the electronic match.

It is logical then that the receiver should be semi-automatic to allow the operator, at his option, to select various stations to adjust tracking gates to the cycle necessary to increase range. The receiver should also be automatic in the sense that once the tracking gates are phase-locked to the pulses, the receiver will continue to provide time difference information. A great deal of sophistication can be achieved if a computer is added to the system, but it is not necessary to accomplish basic navigation.

When the pulse is displayed on the CRT, it represents the superposition of the transmitted eight pulses; not just the first one received. This, in itself, even on third cycle, provides much greater range. This process is called synchronous detection and it should be incorporated into every receiver because it greatly increases the navigation capability. It further eliminates the possibility of locking a master signal into a slave position or vice versa. It does this through the decoding of the phase of the received signals which also facilitates the automatic search, discrimination, and rejection of long delay skywaves. The long delay skywaves can contaminate the following pulse and appear on the CRT as interlaced sine waves.

On a LORAN C/A receiver, the total set-up time should be from two to five minutes. Initial acquisition is enhanced by the fact that operation of other systems on board the aircraft do not affect the process. All stations within range are simultaneously available and it makes no difference which one is acquired first. In fact, slaves can be used to locate and lock onto the master. Once set up, the receiver will continue to provide time difference readouts without further attention. This is true even after the scope stops providing displays. In fact, the scope should not be used, except for initial alignment, because it is much less reliable than the tracking circuits in the receiver. The receiver will track signals 20db below the noise, but the scope will not be able to display the same signal distinct from the noise.

It should be pointed out that for reasons of accuracy, it is important during acquisition to select a cycle in the pulse that is free of skywave interference; usually the third or fourth cycle. However, the particular cycle is of secondary importance to the necessity of selecting the same cycle in the master and slave pulses. The error involved by a one cycle difference is at least a mile, while the error associated with tracking on the fourth cycle is not greater than 200 yards. In this regard, the operator refers to the CRT and visually aligns the gate pulse with the third cycle during acquisition. This alignment is augmented by an electronic cycle-matching circuit in a process called indexing. A meter is provided to indicate

when the third cycle is selected. This circuit operates effectively even when in a quite noisy environment where the CRT is unusable.

The reliability of LORAN C transmissions and the features described previously make this system a natural for effective use of preflight planning.

Even though the departure point is not within the coverage area of a LORAN C chain, the signal is out there waiting for you to fly into it. All you need to do is set in the chain and station parameters and, once you get within range, the set will be providing lines of position continuously while in that area. Techniques, such as estimating the skywave (1 hop E) distances from a station and then indexing the receiver the appropriate number of jumps into the pulse, can aid in acquiring signals outside of the ground wave. The same thing applies when flying from one chain to the next or flying into a chain.

Experience and training are necessary to become truly proficient in the use of any nav aid. However, LORAN C equipment makes navigation with LORAN immeasurably easier and more accurate. LORAN fixing is a simple matter of reading the time differences that are always present and marking the corresponding point on a chart. The only time it is necessary to refer to a scope is during the initial acquisition or in areas of skywave and groundwave mixture. Acquisition itself is a two to five minute process and is free of interference from other aircraft systems. The accuracy and reliability of modern LORAN C equipment and transmission systems cannot be matched by anything at twice the price.

The greatest limitation on the system itself is the lack of user familiarity. There is adequate coverage in the northern hemisphere to support normal air routes across the ocean; the southern hemisphere lacks development in this area. Until now, equipment has not properly exploited the capability inherent in an excellent hyperbolic radio navigation aid. Maybe now that the equipment is available, the user can begin to take advantage of an excellent opportunity to obtain a very cost-effective long range navigation system.

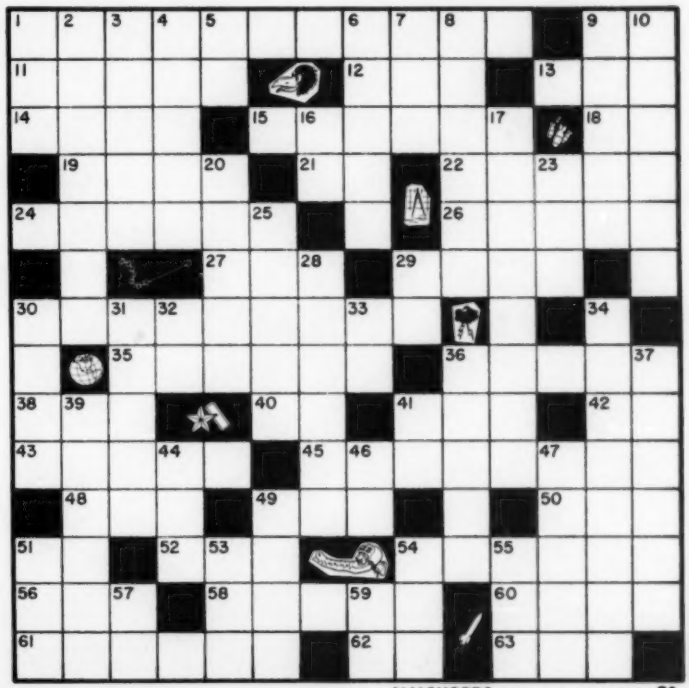
Navwords

ACROSS

1 Low level route
9 A fantasy land
11 Communication aid
12 Body of water
13 Raw metal
14 ___ ___ a far, far better....
15 What recce crews do
18 Instructor nav
19 Part of a house
22 A dangerous place to be flying over
24 A-26 call sign
26 Electronic intelligence
27 ___ lights usually mean trouble
29 What THE NAVIGATOR staff does
30 He was a nav ace
35 Conclusion (two words)
36 Agent 86
38 Mineral spa
40 Not It.
41 Everybody wants to know this
42 For example
43 T-38
45 City in Georgia, et al.
48 Strong alkaline solution
49 Aged
50 Picnic spoiler
51 Diminutive of mother
52 An engine instrument reading
54 Popular name for autopilot
56 Dangerous on ice
58 Form one body
60 These engines can be difficult to start
61 A sign of the Zodiac
62 Exist
63 Sault ___ Marie

DOWN

1 A formal inspection
2 John
3 A unique expression of a language
4 Helmet part
5 Equal opportunity
6 A career broadening program
7 Born
8 Hid
9 Constellation
10 Highest point
16 Mister ___
17 Lucky charm
20 Type of code
23 Troublesome item
25 Prevent
28 ___ floss
29 Letter
30 Symbol on SAC's shield
31 Europe's boot
32 New England state
33 Seat of psychic energy
34 Navigator's ___
36 What MAC crews do
37 Examined
39 Code name for "Apple" program
41 Letter
44 Poetic contraction
46 Score, in football
47 Fortune-telling card
49 VOR
51 ___ 15, 17, et cetera
53 Humorous or suggestive use of a word
54 ___ whiz
55 Old commissioning program
57 Letter
59 Dreaded disease



NAVWORDS answers on page 31

SSNC Revisited

Captain David I. TATMAN
453d Flying Training Squadron
Mather AFB, California

Since your graduation from navigation training, you may still view the world as a series of fixes without a specific destination. As you've gained experience, you may have added the star and wreath to your navigator wings, but have you thought of where your Air Force career is leading? You may have the interest and ability to be an engineer or a manager. You may desire to remain in operations, but feel you have the capability for more responsibility than navigation entails. "I'm a line navigator now," say most navigators, "but isn't there more to being an officer?"

This question is answered every month during the Senior Staff Navigator Course (SSNC) held at Mather AFB, California. Established by Air Staff direction in 1972, SSNC's purpose is to familiarize selected officers with current developments in the navigation career field. Attendees receive information relating to advanced weapons systems and technology, air operations policy and doctrine, new navigation training concepts, and operations management through guest speakers' presentations and information cross-feed.

The most unique feature of the course is that the attendees are the instructors as well as the students. They speak about the advanced systems with which they are associated, explain the policies they helped to develop, and discuss the management techniques they use.

With more and more emphasis on career progression, SSNC illustrates that expansion opportunities into other specialties do exist. Scanning the list of presentations that have been given by the senior navigator attendees points out this fact. In the field of operations, the navigator's role in ADC, AFSC, MAC, PACAF, SAC, TAC, HQ COMD, and USAFE has been discussed. For the engineer or scientist, there have been discussions of the navigator's role in the B-1 program, Eastern Test Range operations, TAC Flight Weapons Test Center, and Systems Command Flight Test programs. Presentations of formal training programs have included Air Training Command's Undergraduate Navigation Training System and

SENIOR STAFF NAVIGATOR COURSE 74-10

Back row;
Lt Col Reed, 22 AF/DOV, Travis AFB; Maj Harrison, 5AF, Fuchu AB; Col Fatiuk, PAS, Fla. St. U.; Maj McNutt, AFLC/XOOF, Wright-Patterson AFB; Lt Col Lauruhn, 96 BW/DOTN, Dyess AFB; Lt Col Holmquist, SAC/DPATO, Offutt AFB.

Front row;
Maj Dees, 35 TFW/DOX, George AFB; Lt Col Borovilos, 456 BW/DOTN, Beale AFB; Maj Parker, 1st ACCS, Andrews AFB; Maj Evans, 323 FTW/DNTI, Mather AFB; Maj Marks, HQ USAF/XOXFCC, Washington DC.

MAJCOM continuation and replacement training. Navigators attending the course have given briefings on their work in the Defense Mapping Agency, Foreign Sales and Training, Air Force Intelligence, Air Force Academy Inspector General's Office and other supplement areas.

These are but a few of the course presentations. The list could go on, but it would only reinforce what is already known— navigators *have* diversified and serve in *every* career field in the Air Force.

Though many attendees have "made-the-grade," even greater opportunities lie ahead. Command, too often thought of only in terms of operational flying units, does exist and is available to the navigator. As the responsibilities and duties of the navigator expand, so will his opportunities.

To prepare for positions of increased responsibility, the senior navigator must also understand the impact and application of policy and doctrine on military operations. He must understand that it is his responsibility to develop younger navigators in officer skills as well as navigation skills. To do this effectively, the senior navigator must also be familiar with a wide range of management and staff techniques. SSNC does not teach any particular technique or system but, with the aid of guest speakers and stimulated discussion, guides the attendees through a free interplay of ideas.

As technology changes, so do the concepts of training and instructional methods. Throughout the course, tours of Mather's new T-43 airborne trainer and a variety of navigation simulators are conducted to demonstrate how effective an instructional systems approach can be. With so many commands represented in the course, suggestions for improvements to the various training programs at Mather are welcomed and solicited.

The role of the navigator is ever changing as more and more opportunities become available. The Senior Staff Navigator Course serves as a vehicle for making the senior navigator, whether technician or supervisor, aware of his potential as an officer and his responsibility to the field of navigation and the Air Force.

Answers to NAVWORDS puzzle from page 29.

1 O	2 L	3 I	4 V	5 E	B	R	6 A	7 N	8 C	H		9 O	10 Z
11 R	A	D	I	O			12 S	E	A		13 O	R	E
14 I	T	I	S		15 D	16 E	T	E	C	17 T		18 I	N
	19 R	O	O	20 M		21 D	R		22 H	A	23 N	O	I
24 N	I	M	R	O	25 D		A		26 E	L	I	N	T
	N			27 R	E	28 D		29 E	D	I	T		H
30 F	E	31 I	32 N	S	T	E	33 I	N		S		34 T	
I		35 T	H	E	E	N	D		36 S	M	A	R	37 T
38 S	39 P	A			40 R	T		41 E	T	A		42 I	E
43 T	A	L	44 O	N		45 A	46 T	L	A	N	47 T	A	S
	48 L	Y	E		49 O	L	D		G		50 A	N	T
51 M	A		52 R	53 P	M			54 G	E	55 O	R	G	E
56 I	C	57 E		58 U	N	I	59 T	E		60 C	O	L	D
61 G	E	M	I	N	I		62 B	E		63 S	T	E	

Guest Cartoonist: **1/Lt Stanley R. SPENCER**

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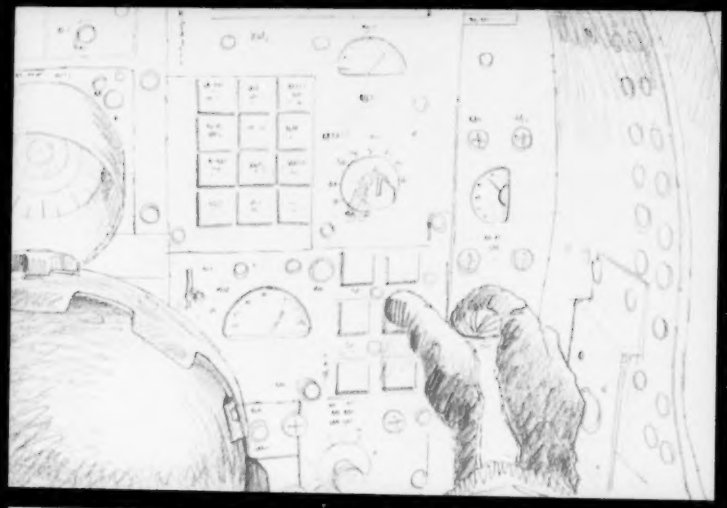

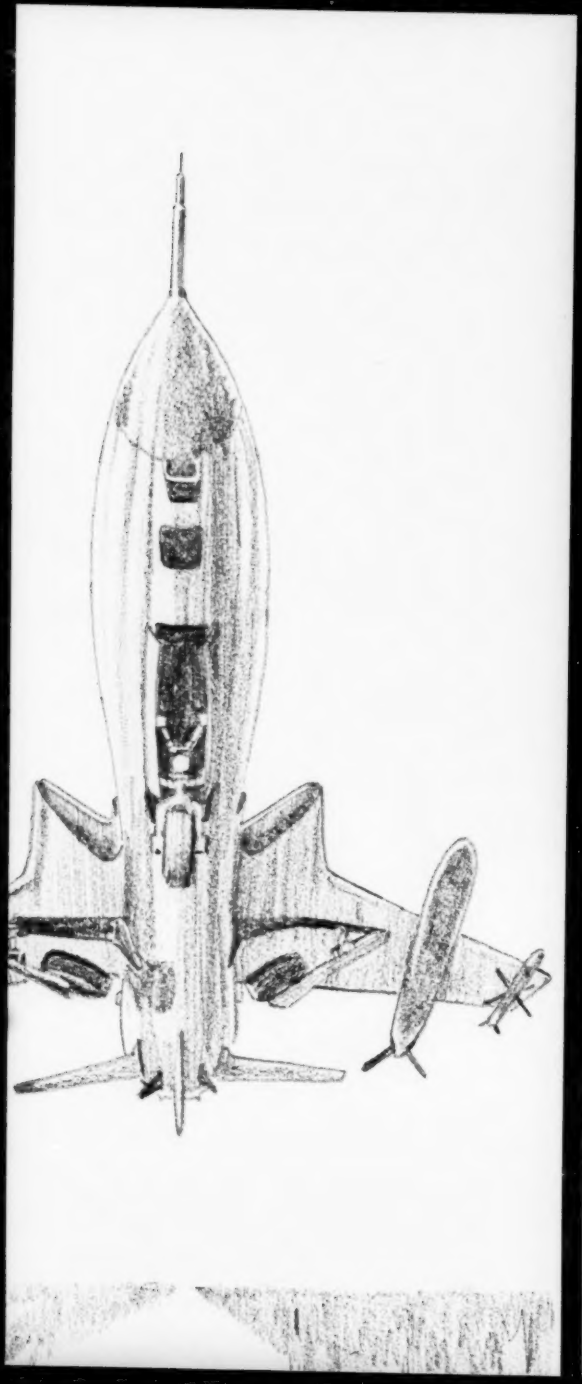

Cave Putorium